New Scientist

WEEKLY 22 March 2025

THE SURPRISING NEW BENEFIT OF GIVING BLOOD

ROLLING ROCKS COULD THREATEN NASA'S MISSION TO TITAN

HOW A MEMORY ILLUSION CAN REWRITE YOUR PAST

OUR SHADOW UNIVERSE

Is our entire cosmos just the edge of a higher dimension?

WEALTH OF KNOWLEDGE
The new psychology of money

PLUS INSECTS SELF-MEDICATE /
THE UNCERTAIN SCIENCE OF CERTAINTY /
CAN YOU REALLY CHANGE YOUR PERSONALITY?

No3535 £6.95 CAN$9.99

Ideas
Happen
Here™
There's no
better time to
invest in a
conversation.
Capital at risk
RBC
Wealth
Management
®/™ Trademark(s) of Royal Bank of Canada. Used under licence.

This week's issue

On the cover

30 Our shadow universe
Is our entire cosmos just the edge of a higher dimension?

38 Wealth of knowledge
The new psychology of money

Vol 265 No 3535
Cover image: iland19, simonkr, manuel_adorf/iStock

18 The surprising new benefit of giving blood

15 Rolling rocks could threaten NASA's mission to Titan

13 How a memory illusion can rewrite your past

34 Insects self-medicate
26 The uncertain science of certainty **27** Can you really change your personality?

38 Features
"Making a financial loss activates similar brain regions to when you experience pain"

News

10 Chatbot revelations
UK politician used AI for advice relating to policy

11 Deep-sea mystery
We may know what is creating "dark oxygen" on the sea floor

14 Pyramid rethink
Surprising skeletons found buried in pyramid tombs

Views

21 Comment
An early-warning system for climate 'tipping points' is an awful idea, says Bill McGuire

22 The columnist
Chanda Prescod-Weinstein on a high-energy neutrino

24 Aperture
Cuneiform tablets bring Mesopotamia back to life

26 Culture
Fight fake news with a great guide to the nature of proof

29 Letters
Is mirror life that big a worry?

STEVE BLOOM IMAGES/ALAMY

19 Penguins at risk Bird flu has reached Antarctica

Features

30 Living on the edge
Our cosmos may be the brink of a wider expanse of reality

34 Creature comforts
Wild animals possess medical knowledge that could also benefit humans

38 Money, money, money
Why do our attitudes towards money vary so much – and what is the healthy view to take?

The back pages

43 Debunking gardening myths
Should you only move growing plants to a pot one size larger?

45 Puzzles
Try our crossword, quick quiz and logic puzzle

46 *Almost* the last word
Could alien life live for many hundreds of years?

47 Tom Gauld for *New Scientist*
A cartoonist's take on the world

48 Feedback
A new Lego set takes a bit of a wrong turn

Elsewhere on New Scientist

Tour

Geology and dinosaurs in Canada

Explore southern Alberta's prehistoric past with geologist and palaeontologist Jon Noad. Journey through the multi-hued canyons and wind-sculpted hoodoos of the iconic Alberta Badlands, which are riddled with dinosaur fossils. Visit Drumheller's pre-eminent dinosaur museum and walk the bone beds of Dinosaur Provincial Park, visiting areas normally off-limits to the general public. You will also spend time exploring the geology of the Rocky mountains. This seven-day tour starts on 16 June and costs £4800.

newscientist.com/tours

SHUTTERSTOCK/RONNIECHUA

Alberta's Badlands Wind-shaped rocks resemble otherworldly structures

Online event

Measuring the mind

Join biologist and neuroscientist Suzana Herculano-Houzel to find out how the human brain became the marvel that it is in a subscriber-only event on 1 April.

newscientist.com/events

Podcast

Weekly

The team discuss how memory may work differently than we thought. Plus, an update on the Trump administration's ongoing attack on science.

newscientist.com/nspod

Video

Survival of the forest

A patch of old oak trees in the UK is helping scientists predict how the world's forests will respond to higher levels of carbon dioxide under climate change.

youtube.com/newscientist

Back in stock

The limited edition *New Scientist* infinity jigsaw puzzle is made from pieces with a single shape that won't ever form a repeating pattern. Available to buy now.

shop.newscientist.com

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456
Email displayads@newscientist.com
Sales director Claudia Nicoletti
Account manager Mila Gantcheva
Agency partner Tilly Pollock

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales director Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events
Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Sales manager Maureen Ignacio
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Events and projects executive Georgia Hill
Events team assistant Olivia Abbott
Events co-ordinator Stephanie Best

New Scientist Discovery Tours
Email tours@newscientist.com
Director Kevin Currie
Senior product manager Lara Paxton
Product manager Pip Orchard

Marketing & Data
Marketing director Jo Adams
Head of campaign marketing James Nicholson
Digital marketing manager Jonathan Schnaider
Campaign marketing coordinator Charlotte Weeks
Head of customer experience Emma Robinson
Engagement marketing manager Kelly Spillane
Head of CRM & audience data Rachael Dunderdale
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Digital marketing designer Katarina Pollu
Junior analyst Hamied Fahim

Technology & Product
Director of strategy and digital transformation Clarissa Agnew
Lead product manager Remy Becher
Director of engineering Michael Ilett
Head of engineering Tom McQuillan
Senior developer and UX designer Amardeep Sian
Senior developers Maria Moreno Garrido, Piotr Walków
Lead digital designer and developer Dan Pudsey
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines

Partnerships
Consultant editor Justin Mullins

NewScientist

Chief executive Roland Agambar
Chief operating officer Jonas Hermans
Chief financial officer Depak Patel
Chair Nina Wright
Executive assistant Lorraine Lodge

Finance & operations
Head of finance Charlotte Lion
Head of finance (maternity cover) Anna Labuz
Finance manager Sam Smith
Finance analyst Milan Novakovic
HR business partner Tinka Bleijenberg

CONTACT US

newscientist.com/contact

General & media enquiries
UK 9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066
US 600 Fifth Avenue, 7th Floor, NY 10020

UK Newsstand
Marketforce UK Ltd
Email mfcommunications@futurenet.com

Syndication
Tribune Content Agency **Tel** +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions
newscientist.com/subscription
One year print subscription (51 issues) UK £270
Tel +44 (0)330 333 9470
Email subscriptions@newscientist.com
Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

© 2025 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd.

ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Warners Midlands Plc

recycle
Once you have finished with this magazine please recycle it.

EDITORIAL

Editor Catherine de Lange
Executive editor Timothy Revell
Managing editor Penny Sarchet
Creative director Craig Mackie

News
News editor Jacob Aron
Assistant news editors
Alexandra Thompson, Sam Wong
Reporters (UK) Madeleine Cuff, Michael Le Page, Matthew Sparkes, Alex Wilkins, Carissa Wong
(Aus) Alice Klein, James Woodford

Digital
Head of audience Matt Hambly
Podcast editor Rowan Hooper
Head of editorial video David Stock
SEO and analytics manager Finn Grant
Social media manager Isabel Baldwin
Video producer Obomate Briggs

Features
Head of features Claudia Canavan
Deputy head of features Joshua Howgego
Editors Abigail Beall, Leah Crane, Kate Douglas, Alison George, Thomas Lewton, Linda Rodriguez-McRobbie
Feature writer Graham Lawton

Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

Magazine
Magazine editor Eleanor Parsons
Assistant magazine editor Michael Dalton

Subeditors
Chief subeditor Kelsey Hayes
Bethan Ackerley, Tom Campbell, Tom Leslie, Jon White

Design
Art editor Ryan Wills
Joe Hetzel, Phoebe Watts

Picture desk
Picture editor Tim Boddy
Assistant picture editor Jenny Quiggin

Production
Production manager Joanne Keogh
Production coordinator Carl Latter

New Scientist US
US editor Chelsea Whyte
Editors Sophie Bushwick, Corryn Wetzel
Subeditor Alexis Wnuk
Deputy audience editor Gerardo Bandera
Reporters James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Grace Wade

FENTON

UNLEASHING

THE WORLD OF

FINE JEWELLERY

Comparison can be verified on
fentonand.co/pricecomps

New Scientist

INTRODUCTORY OFFER
10 WEEKS OF DIGITAL ACCESS *for* £10

Knowledge at your fingertips

Enjoy unlimited digital access to *New Scientist* anytime, anywhere with:

- Trusted health insights to challenge the way you think about your body and mind.
- Expert analysis of the growth of artificial intelligence and our advances in technology.
- The latest in discoveries around the multiverse, dark matter and the world of physics.

Subscribe now and pay just ~~£5~~ £1 a week

newscientist.com/fingertips

or call +44 (0) 330 333 9470, quoting 22017

Print and digital packages also available. These are auto-renewing subscriptions which can be cancelled at any time. In the unlikely event that you wish to cancel your subscription, we offer a 14-day cooling off period after the initial payment is made. Offer ends 13 May 2025.

AI meets policy

Government use of chatbots challenges whether we can think of the tools as "smart"

GREGGORY DISALVO/GETTY IMAGES

WHAT is artificial intelligence? It is a question that scientists have been wrestling with since the dawn of computing in the 1950s, when Alan Turing asked: "Can machines think?" Now that large language models (LLMs) such as the one behind ChatGPT have been unleashed on the world, finding an answer has never been more pressing.

While their use has already become widespread, the social norms around these new AI tools are still rapidly evolving. Should students use them to write essays? Will they replace your therapist? And can they turbocharge government?

That last question is being asked in both the US and the UK. Under the new Trump administration, Elon Musk's Department of Government Efficiency task force is eliminating federal workers and rolling out a chatbot, GSAi, to those who remain. Meanwhile, UK Prime Minister Keir Starmer has called AI a "golden opportunity" that could help reshape the state.

Certainly, there is government work that could benefit from automation, but are LLMs the right tool for the job? Part of the problem is that we still can't agree on what they actually are. This was aptly demonstrated last week, when *New Scientist* used freedom of information (FOI) laws to obtain the ChatGPT interactions of Peter Kyle, the UK's secretary of state for science, innovation and technology (see page 10). Politicians, data privacy experts and journalists – not least us – were stunned that this request was granted, given similar requests for, say, a minister's Google search history, would generally be rejected.

That the records were released suggests that the UK government sees using ChatGPT as more akin to a ministerial conversation with civil servants via email or WhatsApp, both of which are subject to FOI laws. Kyle's interactions with ChatGPT don't indicate any strong reliance on the AI for forming serious policy – one of his questions was about which podcasts he should appear on. Yet the fact that the FOI request was granted suggests that some in government seem to believe the AI can be conversed with like a human, which is concerning.

"AIs should not be viewed as intelligent agents, but as a new cultural and social technology"

As *New Scientist* has extensively reported, current LLMs aren't intelligent in any meaningful sense and are just as liable to spew convincing-sounding inaccuracies as they are to offer useful advice. What's more, their answers will also reflect the inherent biases of the information they have ingested.

Indeed, many AI scientists are increasingly of the view that LLMs aren't a route to the lofty goal of artificial general intelligence (AGI), capable of matching or exceeding anything a human can do – a machine that can think, as Turing would have put it. For example, in a recent survey of AI researchers, about 76 per cent of respondents said it was "unlikely" or "very unlikely" that current approaches will succeed in achieving AGI.

Instead, perhaps we need to think of these AIs in a new way. Writing in the journal *Science* last week, a team of AI researchers says such tools "should not be viewed primarily as intelligent agents but as a new kind of cultural and social technology, allowing humans to take advantage of information other humans have accumulated".

The researchers compare LLMs to "such past technologies as writing, print, markets, bureaucracies, and representative democracies" that have transformed the way we access and process information.

Framed in this way, the answers to many questions become clearer. Can governments use LLMs to increase efficiency? Almost certainly, but only when used by people who understand their strengths and limitations. Should interactions with chatbots be subject to FOI laws? Possibly, but existing carve-outs designed to give ministers a "safe space" for internal deliberation should apply. And can, as Turing asked, machines think? No. Not yet. ▮

Get ready for a very special new launch in April.
Last time we did this, with our C1 Bel Canto, it ruffled more than a few feathers amongst the ultra-conservative watchmaking establishment. It also sold out in a matter of hours and firmly established our credentials as designers and makers of the very highest calibre. What next? All will be revealed in April.
Sign up now for more clues – before everyone gets in a flap.

Do your research

Christopher Ward

christopherward.com

News

Puzzle solved
Solution found to a century-old maths challenge p12

Early Europeans
Face bones hint at first humans in Europe p16

Weird asteroid
Asteroid Bennu is even stranger than we thought p16

Carbon capture
Can forests soak up the extra CO_2 we are emitting? p17

Thinnest metal
Metals squeezed into sheets just a few atoms thick p18

ESA/EUCLID/EUCLID CONSORTIUM/NASA, IMAGE PROCESSING BY J.-C. CUILLANDRE, E. BERTIN, G. ANSELMI

Space

A close-up look at far-away galaxies

On 19 March, the European Space Agency released the first survey results from its Euclid space telescope. This picture comes from one of its deep-field observations, which are looking at three parts of the sky in incredible detail. A number of galaxy clusters are visible, some of which are located nearly 6 billion light years away from Earth.

Cosmology

Our best understanding of the universe may be wrong...

Karmela Padavic-Callaghan

DARK energy is one of the most mysterious features of our universe – we don't know what it is, but it controls how the universe is expanding, as well as its ultimate fate. Now, a study of millions of celestial objects has revealed that we may have been thinking about it all wrong, with potentially dramatic consequences for the cosmos.

"This is the biggest hint we have about the nature of dark energy in the approximately 25 years since we discovered it," says Adam Riess at Johns Hopkins University in Maryland.

The result comes from three years' worth of data gathered by the Dark Energy Spectroscopic Instrument (DESI) in Arizona. By combining this data with other measurements, such as maps of the cosmic microwave background radiation and supernovae, the DESI team has concluded that dark energy may have changed over time – directly contradicting the standard model of cosmology, called lambda-CDM.

Cutting-edge knowledge

"This is the cutting edge of human knowledge," says DESI team member Will Percival at the University of Waterloo in Canada. "We're seeing something amazing with the whole universe."

DESI is mounted on a telescope and works by measuring the "redshift" of light emitted by distant galaxies, or how the wavelengths of that light are stretched as it travels through the universe. From this, researchers can determine how much the universe has expanded during the light's journey and calculate how this expansion is changing. So far, the team has analysed light from nearly 15 million galaxies and other bright objects in the sky.

For decades, physicists have agreed that the universe is expanding at a fixed rate of acceleration, a cosmological constant known as lambda that has been interpreted as the push of dark energy. But in April 2024, DESI's measurements showed

"This is the biggest hint we have about the nature of dark energy since we discovered it"

the first hints that the universe may actually be accelerating less quickly over time – making the cosmological constant not so constant.

Riess, who isn't on the DESI team, says that, at the time, he wasn't sure whether the finding would persist with more data. In fact, it has only become stronger. "It's very exciting to me that it appears that [the team] did not find any problem in the analysis after another year, and after they've added more data. If anything, the result is more significant," he says.

That said, the finding still doesn't meet the "5 sigma" statistical level that physicists conventionally use to mark a discovery as genuine, rather than a statistical fluke. The current analysis reaches at most 4.2 sigma, but team member Mustapha Ishak-Boushaki at the University of Texas at Dallas says the team believes that, as DESI keeps taking data, the result should hit 5 sigma within two years. "This result about dark energy is something that we did not expect to happen in our lifetime," he says.

One reassurance, says Ishak-Boushaki, is that the finding doesn't rely only on data from DESI, but also on several other surveys of the universe. Riess compares the situation to a multi-legged stool, where breaking one leg – or removing one dataset – doesn't make the conclusion fully crumble.

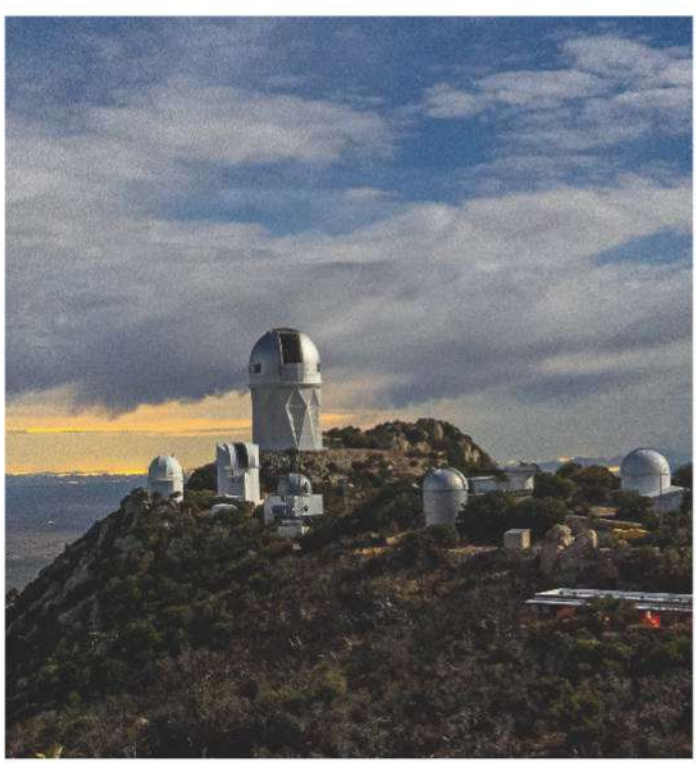
Weaker dark energy

Assuming the legs hold, the universe could look very different from our current picture of it. If dark energy keeps becoming weaker, the universe may reach a state where it is expanding at a constant rate instead of faster and faster, says Ishak-Boushaki. Some dramatic scenarios also become more plausible, such as the "big crunch", where the cosmos starts contracting instead of expanding and eventually collapses in on itself, he says.

The exact future of the universe remains an open question, and DESI isn't the only tool researchers are using to answer it. Riess points to several other surveys of the universe, such as NASA's Nancy Grace Roman Space Telescope and the Vera Rubin Observatory in Chile, which are designed to help shed light on the true nature of dark energy.

While mathematical models for a universe with changing dark energy still need to catch up with these observations, Percival says he expects future theoretical work will help design even more experiments that will directly test our assumptions about this mysterious force.

"As far as theoretical models, Pandora's box just opened. We were stuck with a cosmological constant," says Ishak-Boushaki. "We are not stuck anymore." ▮

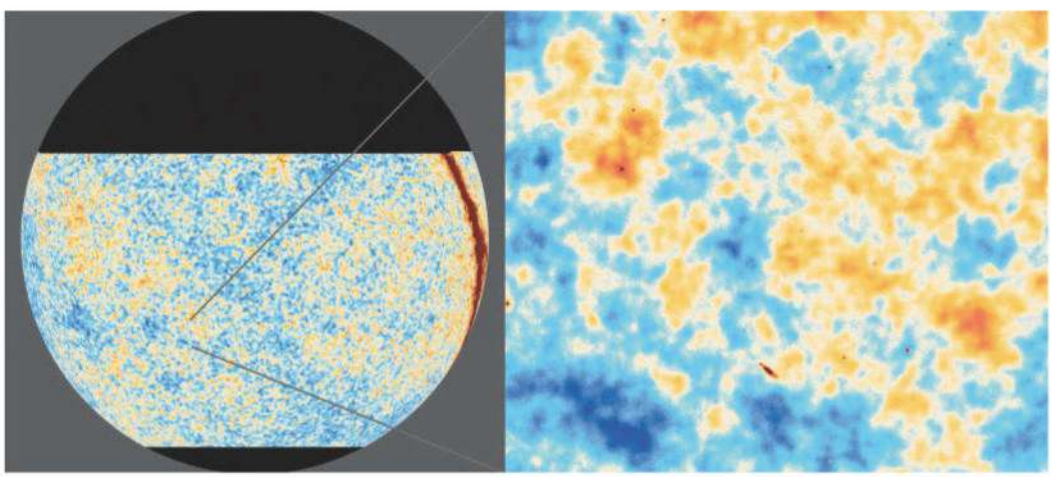


MARILYN SARGENT/UNIVERSITY OF CALIFORNIA/LAWRENCE BERKELEY NATIONAL LABORATORY

The DESI survey is being conducted on the Mayall 4-metre telescope in Arizona

...or it may be too right

The finest ever map of the cosmic microwave background suggests our best model of the universe works just fine, making it hard to know where cosmologists go next, finds **Matthew Sparkes**



ACT COLLABORATION; ESA/PLANCK COLLABORATION

More intense (orange) and less intense (blue) radiation shown in the new CMB image

OUR latest and best ever map of the early universe is five times more detailed than anything we have had before, but while it precisely backs up the leading model of the universe, it is also a double-edged sword because it offers no clues to solving some of cosmology's biggest mysteries.

The map shows the cosmic microwave background (CMB), a faint remnant radiation from the early stages of the universe. It began as the earliest light, just 380,000 years after the big bang, but billions of years of the universe expanding have shifted its frequency from the visible spectrum to microwave.

Now, new data from the Atacama Cosmology Telescope (ACT) has given us a clearer image of the CMB – albeit only from the half of the sky that can be imaged from the observatory's location in Chile.

Jo Dunkley at Princeton University, who worked on the project, says that the data has given us a more precise look at the ingredients of the universe, its size, its age and its expansion rate. But the really key discovery was that nothing contradicted the current leading model of the universe, known as lambda-CDM.

Previous data put the age of the universe at 13.8 billion years and the rate at which it is expanding – known as the Hubble constant – at 67 to 68 kilometres per second per megaparsec distance from Earth. ACT data essentially confirms this, at higher precision. The Hubble constant is related to, but distinct from, the cosmological constant that drives dark energy (see left)

The CMB was first mapped by NASA's Cosmic Background Explorer (COBE) in the 1980s and 90s, then by NASA's Wilkinson Microwave Anisotropy Probe (WMAP) in the 2000s and then in yet greater detail by the European Space Agency's Planck spacecraft from 2009 to 2013. Each mission provided more detailed maps of the CMB, advancing our knowledge of cosmology and understanding of the early universe.

One limitation of ACT is that it is a ground-based telescope, unlike these earlier, space-based missions, which is why it is limited to just one half of the sky. Despite this, ACT gives not only better resolution and sensitivity than these previous maps, but it also measures the polarisation of the CMB, or the orientation in which its light waves oscillate, revealing some information about how the CMB radiation has evolved.

"We were quite ready to see something departing from the standard model, some subtlety. But we haven't"

"By looking at the polarisation of the CMB in better detail, we could have seen something different. We could have seen the standard cosmological model breaking," says Dunkley. "Because whenever you look at the universe in a different way, you can't be sure that your original model is still going to work. We were quite ready to see something departing from that model, some subtlety. But we haven't."

This may be reassuring for those working on lambda-CDM, but hasn't been welcome news for all scientists. Colin Hill at Columbia University in New York says that he was hoping to see evidence for an unexplained phenomenon – perhaps a new type of energy or particle – which could help explain the so-called Hubble tension: the discrepancy between the rate of expansion in the universe given by the lambda-CDM standard model and what we measure directly.

"We've all just been blown away by how consistent [the ACT data] really is with the standard model. We're all trying to poke and prod the model from different aspects and look for a place where it's going to crack, and where nature will give us something to sink our teeth into. And so far, nature hasn't yielded that crack," says Hill.

He says that the most viable theories for the Hubble tension discrepancy require phenomena that don't appear in the ACT data, which is currently the best we have. This will force scientists back to the drawing board to seek another explanation. "The new measurements are going to put theorists, including myself, into an even tighter straitjacket," says Hill. "It deepens the mystery."

ACT collected the data for this new map between 2017 and 2022, but has now been shut down. Dunkley says that we are unlikely to get a higher resolution map soon, although a new telescope in Chile will start work later this year. As for the other half of the sky, only two locations on Earth are likely to be able to host new telescopes that would yield results: Greenland and Tibet. Dunkley says that Greenland doesn't yet have the necessary infrastructure for such a project, and Tibet is politically sensitive.

Jens Chluba at the University of Manchester, UK, says that while scientists on the project have already been working with the data, the open release of the map will spark a flurry of activity. "The whole cosmology community can get their hands on the data and do all kind of cross-analysis with their datasets," says Chluba. ▮

Artificial intelligence

UK politician used AI for policy advice

In what is believed to be a world first, *New Scientist* has used freedom of information laws to obtain the ChatGPT records of the UK's technology secretary, says **Chris Stokel-Walker**

THE UK's technology secretary, Peter Kyle, has used ChatGPT for advice relating to policy, *New Scientist* can reveal, following a request for information from the UK government.

Last week, UK Prime Minister Keir Starmer said that the government should be making far more use of AI in an effort to increase efficiency. "No person's substantive time should be spent on a task where digital or AI can do it better, quicker and to the same high quality and standard," he said.

Now, *New Scientist* has obtained records of Kyle's ChatGPT use under the Freedom of Information (FOI) Act, in what is believed to be a world-first test of whether chatbot interactions are subject to such laws. These records show that Kyle asked ChatGPT to explain why the UK's small and medium business (SMB) community has been slow to adopt AI. ChatGPT returned a 10-point list of possible reasons, including sections on "Limited Awareness and Understanding", "Regulatory and Ethical Concerns" and "Lack of Government or Institutional Support".

The chatbot advised Kyle: "While the UK government has launched initiatives to encourage AI adoption, many SMBs are unaware of these programs or find them difficult to navigate. Limited access to funding or incentives to de-risk AI investment can also deter adoption." It also said, concerning regulatory and ethical concerns: "Compliance with data protection laws, such as GDPR [a data privacy law], can be a significant hurdle. SMBs may worry about legal and ethical issues associated with using AI."

"As the Cabinet Minister responsible for AI, the Secretary of State does make use of this technology. This does not substitute comprehensive advice he routinely receives from officials," says a spokesperson for the Department for Science, Innovation and Technology (DSIT), which Kyle leads. "The Government is using AI as a labour-saving tool – supported by clear guidance on how to quickly and safely make use of the technology."

TAYFUN SALCI/ZUMA PRESS WIRE/SHUTTERSTOCK

Peter Kyle, the UK's technology secretary, used ChatGPT for work

Podcast picks

Kyle also used the chatbot to canvas for ideas for media appearances, asking: "I'm Secretary of State for science, innovation and technology in the United Kingdom. What would be the best podcasts for me to appear on to reach a wide audience that's appropriate for my ministerial responsibilities?" ChatGPT suggested *The Infinite Monkey Cage* and *The Naked Scientists*, based on their number of listeners.

As well as seeking this advice, Kyle asked ChatGPT to define various terms relevant to his department: antimatter, digital inclusion and quantum. Two experts *New Scientist* spoke to say they were surprised by the quality of the responses when it came to ChatGPT's definitions of quantum. "This is surprisingly good, in my opinion," says Peter Knight at Imperial College London. "I think it's not bad at all," says Cristian Bonato at Heriot-Watt University in Edinburgh, UK.

New Scientist made the request for Kyle's data following his recent interview with *PoliticsHome*, in which the politician was described as "often" using ChatGPT. He said that he used it "to try and understand the broader context where an innovation came from, the people who developed it, the organisations behind them" and that "ChatGPT is fantastically good, and where there are things that you really struggle to understand in depth, ChatGPT can be a very good tutor for it".

"Kyle asked ChatGPT why the UK's small and medium business community has been slow to adopt AI"

DSIT initially refused *New Scientist*'s FOI request, stating: "Peter Kyle's ChatGPT history includes prompts and responses made in both a personal capacity, and in an official capacity". A refined request, for only the prompts and responses made in an official capacity, was granted.

Precedent setting

The fact the data was provided at all is a shock, says Tim Turner, a data protection expert based in Manchester, UK, who thinks it may be the first case of chatbot interactions being released under FOI. "I'm surprised that you got them," he says. "I would have thought they'd be keen to avoid a precedent."

This, in turn, poses questions for governments with similar FOI laws, such as the US. For example, is ChatGPT more like an email or WhatsApp conversation – both of which have historically been covered by FOI – or the results of a search engine query, which traditionally have been easier for organisations to reject? Experts disagree on the answer.

"In principle, provided they could be extracted from the department's systems, a minister's Google search history would also be covered," says Jon Baines at UK law firm Mishcon de Reya.

"Personally, I wouldn't see ChatGPT as being the same as a Google search," says John Slater, an FOI expert. That is because Google searches don't create new information, he says. "ChatGPT, on the other hand, does 'create' something based on the input from the user."

With this uncertainty, politicians might want to avoid using privately developed commercial AI tools like ChatGPT, says Turner. "It's a real can of worms," he says. "To cover their own backs, politicians should definitely use public tools provided by their own departments as if the public might end up being the audience." ▮

Environment

We may have discovered how 'dark oxygen' is being made in the deep sea

Michael Le Page

METALLIC nodules found deep in the sea seem to be producing significant amounts of oxygen by some unknown mechanism, researchers revealed last year. Now, we may have found out how it is happening – and the same process could also produce oxygen to help terraform Mars.

Chaomin Sun at the Chinese Academy of Sciences in Beijing and his team have discovered that two species of deep-sea bacteria can produce large quantities of oxygen. What's more, this process might form metallic nodules as a side effect, explaining why these minerals seem to produce this "dark" oxygen.

"I am very surprised by the amount of oxygen production by these deep-sea bacteria," says Sun. "This pathway operates independently of solar radiation and photosynthesis."

The scientific orthodoxy is that all the oxygen in the oceans comes from photosynthesis – the light-driven splitting of water by organisms in the upper waters into oxygen and hydrogen. In recent years, it has been discovered that a few bacteria and archaea can produce oxygen in the dark, but the quantities are so small they weren't thought important.

Then in 2013, Andrew Sweetman at the Scottish Association for Marine Science detected oxygen production on the abyssal plain, thousands of metres down. He dismissed it as an instrument error, but when he found the same thing again years later, he began investigating.

Last year, his team published a controversial paper claiming that metallic nodules on the seabed produce enough oxygen to shape local ecosystems and might have even played a role in the evolution of life. But critics raised various objections, including pointing out that the nodules contain manganese oxide that can form only if oxygen is already present – probably ruling this process out as relating to the first life.

Now Sun's team has shown that when two strains of deep-sea bacteria are grown in the presence of nitrate ions, they reduce it to ammonium, releasing oxygen in the process – a previously unknown reaction. "The dissolved oxygen concentration is over 300-fold higher than that produced by a previously reported ammonia-oxidising archaea," says Sun.

"I think this dark oxygen production is widespread. We're just starting to scratch the surface here"

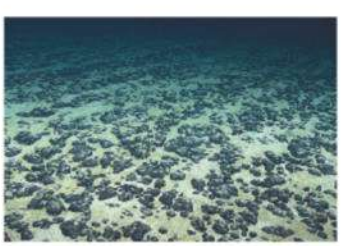
Such oxygen could be crucial for some oxygen-dependent microbes and even small animals, the team suggests, both on Earth and perhaps elsewhere, too. "Microbial dark oxygen could be a significant oxygen source in nitrate-rich ocean worlds, even in the absence of light," the team's paper states. Nitrates have been found on Mars, so this process could help terraform the planet, the team suggests. "The concentrations are sufficient to support the microbial nitrate-dependent anaerobic oxygen production we propose," says Sun.

What's more, Sun's team also found that when manganese is present, manganese oxide precipitates out, suggesting the metallic nodules could be formed by bacteria (bioRxiv, doi.org/pb54).

Sweetman says the findings could explain the oxygen production his team reported. "It's all very exciting." Nitrates are plentiful in the sediments on the seafloor, he says. "So you have quite a lot of stuff that can be used for this process."

His team did try to rule out a microbial explanation by adding a poison to kill off any microbes, leading them to instead suggest an electrochemical process might be involved. "[But] we could not guarantee that the poison seeped into all of the available pore-spaces in the sediment and nodules," says Sweetman.

Manganese nodules on the seafloor may be created by bacteria



NOAA

CHARLES D. WINTERS/SCIENCE PHOTO LIBRARY

Going deeper

Other explanations for the oxygen production remain possible, he says. "We are still in the process of trying to figure out what is causing it."

"The thing that's key here, I think, is that almost every couple of months we're discovering a new process that microbes carry out, which we didn't think possible," says Sweetman.

But Don Canfield at the University of Southern Denmark isn't convinced by Sun's findings. "If true, the results would be outstanding, but I have many concerns," he says, adding that he is sceptical that a process like this is a significant source of oxygen in the deep ocean.

"We'll see where we are in the next five years," says Sweetman. "I think this dark oxygen production is widespread. We're just starting to scratch the surface here."

One reason why his claim of oxygen production involving metallic nodules is so controversial is that companies are interested in mining such minerals. The findings suggest deep-sea extraction of nodules would have a bigger impact than currently thought. If the nodules and top 10 centimetres of sediment were removed, it would take 100,000 years for the ecosystem to return to the same state, says Sweetman.

"I'm not for mining, but I'm not against it," he says. "But I think you need to be mindful of just how long these systems will take to recover." ▮

Mathematics

Century-old maths puzzle solved

A challenge, first set in 1900, to bring together equations relating to particles and fluids under one mathematical framework has been solved, finds **Karmela Padavic-Callaghan**

MATHEMATICIANS have finally succeeded in unifying the laws of physics that govern the motions of particles at different scales. Their efforts resolve a question set by mathematician David Hilbert in 1900 as part of an ambitious programme for all mathematicians of the 20th century – and could deepen our understanding of the complex behaviour of fluids in the atmosphere and oceans.

"This is a major result in my view. I thought it was completely beyond reach," says Benjamin Texier at the University of Lyon in France.

Specifically, Zaher Hani at the University of Michigan and his colleagues have demonstrated how to consistently and meaningfully stitch together physical laws at three different scales.

First, there is the microscopic realm of single particles colliding with each other in accordance with Isaac Newton's laws of motion. In the mesoscopic realm of larger objects, collections of such particles instead follow statistical laws pioneered by Ludwig Boltzmann.

Balancing the scales

At the even larger macroscopic scale, where we reside, physicists turn to notoriously difficult mathematical tools such as the Navier-Stokes equation, which captures all the intricacies of how a fluid behaves.

Over the years, physicists and mathematicians have established some links between the three frameworks, but until now they were never fully united. The quest to do so began in the 19th century, says Hani, after Boltzmann presented his statistical techniques and his contemporaries clamoured for a rigorous mathematical proof that they actually worked. This ultimately morphed into the sixth problem on Hilbert's agenda, which calls for a derivation of laws dictating the behaviour of fluids from the most basic, bare-bones mathematical axioms.

"One reason this was so desirable is because some of these laws are reversible in time and some are not"

One reason this was so desirable is because some of these laws are reversible in time and some are not, says team member Yu Deng at the University of Chicago. For instance, Newton's laws are not sensitive to the direction of time's flow, which renders "before" and "after" interchangeable, while Boltzmann's statistical equations suggest a way to demarcate the two. Deng says that his team's work, which has been ongoing for more than half a decade, elucidates when and how this switch happens, eliminating the possibility of a time-related mathematical paradox.

A key ingredient of the team's approach relies on recasting calculations in terms of diagrams originated by the physicist Richard Feynman, who used them for tackling problems in quantum field theory. Mathematicians have learned to use these diagrams to tackle difficult equations for particles that repeatedly interact with each other, as occurs in a fluid, but Hani says this can become overwhelming. The team instead found a way to reduce the number of diagrams it had to calculate exactly, which allowed it to build a mathematical path from Newton's laws to the Navier-Stokes equation (*arXiv*, doi.org/pbs6).

Texier says that while there is a long history of partial solutions to Hilbert's sixth problem, the new work is a "real leap forward", validating both the way Hilbert posed the problem and the intuition behind Boltzmann's original work. In other words: the new proof reaffirms the way physicists have been thinking about fluids and gases for more than a century, while guaranteeing a firm mathematical foundation. But Hani says the team doesn't feel like its work closes the book on Hilbert's quest.

Breaking point

"The importance of [Hilbert's sixth] problem is really not just in terms of axiomatising the laws of physics, but it's also in terms of understanding the implications of these [mathematical] models. We know that they break down at some point. I think the modern motivation for Hilbert's [sixth] problem should be in terms of understanding what happens when those models break," he says.

Deng is particularly interested in what happens at the smallest, most microscopic scale, when the more macroscopic fluid equations develop singularities, in other words when their solutions become meaningless. This can happen in a broad range of situations in oceanography and atmospheric science, but the researchers may now be able to get an exact picture because of their rigorous connection between the two scales.

For Texier, all the implications of the new work are not yet clear, simply because it is such a rich and complex piece of mathematics. "I think it's going to take a lot of effort for the community to digest it," he says.

SHUTTERSTOCK/AMANDA JANE FRANCIS IMAGE

This discovery could help us better understand the movement of oceans

Mind

Memory trick makes you think events occurred earlier than they did

Sophie Berdugo

AN ILLUSION that warps our perception of time – altering our recollection of events to make it seem as if they occurred further into the past – may force a rethink of our theories of memory.

Our ability to recall past events requires information on what happened as well as when and where, but because memories aren't time-stamped, our recollection of when they were formed is fallible. For example, previous studies have found that seeing a name multiple times can lead people to believe they had encountered it more recently than was truly the case.

One way to explain this is that repeated experiences trigger our memory of the previous occasion, potentially strengthening the original memory. Intuitively, a stronger memory might be expected to be more recent, as our memories of events can fade over time. But Brynn Sherman at the University of Pennsylvania says these findings didn't tally with her and her colleagues' personal experiences of memory.

INNIS MCALLISTER/MILLENNIUM IMAGES, UK

Study participants put images in order based on which they saw first

To investigate further, the team ran a series of experiments to see how repeatedly viewing an image affected people's perception of when they had first seen it. Although these experiments varied, participants were generally shown five blocks of 50 images, with some of the images shown just once across all the blocks and some repeated two, three or five times. They were then asked to place when they had seen each image along a timeline.

The researchers found that not only did participants have a better memory of images they had seen more than once, they also remembered the repeated images as having first appeared earlier than they actually did (PsyArXiv, doi.org/pbsz). The size of this "temporal repetition effect" scaled with the number of repetitions: images repeated five times were remembered as having been encountered further back than items repeated three times, and so on.

Participants may have tried to figure out when they had first seen an image by using certain strategies, like presuming that something must have first occurred longer ago if it could be repeated, says Sherman. But when she asked participants if they had used any rules of thumb, these didn't actually match the way they had ordered the images. "So we do think it might be some genuine memory effect, not just a heuristic," she says.

To test whether the illusion remained over a longer time period, the researchers ran one experiment over a week, with the participants seeing a block of 100 images each day from Monday

"Because memories aren't time-stamped, our recollection of when they were formed is fallible"

to Friday and then completing the memory test the following Monday. Crucially, the participants still experienced the effect.

Alexander Easton at Durham University, UK, says the finding is hard to reconcile with our current understanding of memory. However, Martin Wiener at George Mason University in Virginia says it could be explained by magnitude-based theories of time, which suggest that our brain remembers large objects better than small ones. "It's possible that by having the repeated events like this over and over again, the magnitude of time for that event has grown," says Wiener. ▮

Solar system

Mysterious summer marsquakes shake the Red Planet

THOUSANDS of quakes on Mars that only happen during the northern hemisphere summer are puzzling scientists.

Simon Stähler at the Swiss Federal Institute of Technology in Zurich and his colleagues have found thousands of curious marsquakes detected by NASA's InSight lander that are unlike anything we have spotted on Earth. These quakes are rocking the planet at similar intensities each time and only happen during the summer. "None of this is normal," Stähler told the Lunar and Planetary Science Conference in Texas on 10 March.

The quakes seem to only happen in the north of Mars, shaking the planet 10 times a day at their peak and then ceasing for the rest of the year. Stähler and his team saw this pattern during two consecutive Martian summers, with the second summer experiencing twice as many quakes as the first.

The clustered timing is "the weirdest thing about these quakes", said Stähler. On Earth, the only mechanism we know for seasonal earthquakes is increased rainfall

ESA & MPS FOR OSIRIS TEAM

NASA'S InSight lander has recorded thousands of quakes on Mars since 2018

temporarily changing the rock composition. But Mars's surface lacks liquid water, so that can't be why this happening, said Stähler.

As earthquakes become stronger in magnitude on the Richter scale, they also tend to become around 10 times less frequent compared with weaker ones. But the strongest marsquakes were up to 1000 times less frequent than weaker ones.

"The real mystery, and the part that makes this very exciting, is the seasonality," says Michael Sori at Purdue University in Indiana. Mars has seasonal processes, such as carbon dioxide-based ice that grows and retreats annually, which has been linked to avalanches, says Sori. However, these avalanches are distant from where the marsquakes were detected. "Maybe there's some sort of equivalent seasonal process involving carbon dioxide ice at a different location that could be part of the answer," says Sori. ▮

Alex Wilkins

Archaeology

Surprising skeletons prompt a rethink of Egyptian pyramids

Colin Barras

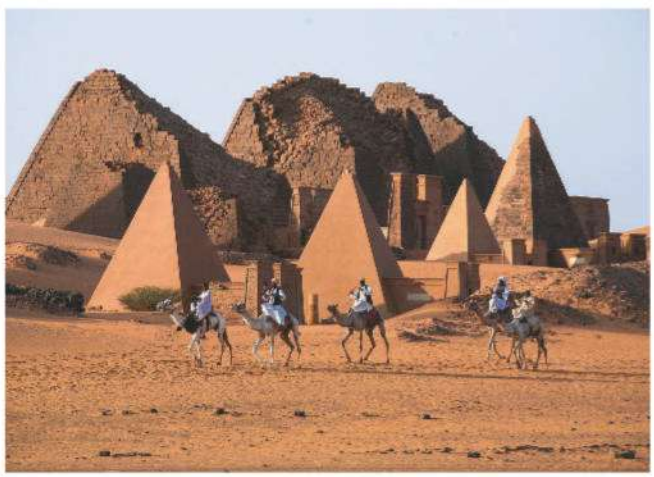
ARCHAEOLOGISTS have long assumed that ancient Egyptian pyramids were reserved for the richest members of society – but an analysis of burials at a site called Tombos suggests low-status workers could merit a place in pyramid tombs, too.

Tombos, an archaeologicasl site in northern Sudan, came under ancient Egyptian control about 3500 years ago when the famous civilisation was at its most powerful. By this time, Egyptian royalty no longer favoured pyramid burials. But Egyptian nobles were still keen on them, and the ruined remains of at least five mud-brick pyramids have been found at Tombos.

Sarah Schrader at Leiden University, the Netherlands, has been working at the site for more than a decade. In particular, she has been determining how active Tombos's ancient inhabitants were during their lives by analysing subtle marks on their bones where muscles, tendons and ligaments once attached.

When she and her colleagues examined the numerous skeletons associated with each pyramid tomb, they made an unexpected discovery: some of the remains belonged to people who had done very little physical activity during their lives, and others belonged to people who had been extremely active (*Journal of Anthropological Archaeology*, doi.org/pbs5).

"At first we didn't quite understand what the data meant," says Schrader. Her colleague, Stuart Tyson Smith at the University of California, Santa Barbara, came up with an explanation: the low-activity individuals must have been nobles who lived in luxury – and the active individuals must have been hard-working non-elites. This challenges a long-standing assumption in Egyptology that monumental tombs were exclusively reserved for nobles.



WEN TAO/XINHUA/IMAGO/ALAMY

The brick pyramids at Tombos were probably similar to those at other sites in Sudan, such as these at Meroë

"I think we have assumed for far too long that pyramids were just for the rich," says Schrader.

Alternative explanations are possible, says Aidan Dodson at the University of Bristol, UK. For example, the high-activity individuals may have been nobles who chose to keep in good physical shape to reinforce their status.

> "I think we have assumed for far too long that pyramids were just for the rich"

But Schrader isn't convinced. She and her colleagues point out in their study that plenty of archaeological evidence from elsewhere indicates that ancient Egyptian elites had strictly different activity patterns from non-elites.

It is also unlikely that there is a sinister explanation for the co-occurrence of nobles and workers in the same tomb, says Schrader. "[Human] sacrifice had occurred in the region about 500 years prior," she says – but by the time Tombos was under ancient Egyptian control "there's really no evidence for it".

Her team speculates that the non-elites may have been servants who were buried in the pyramids so they could continue to serve their masters in the afterlife. That's a surprising conclusion: although ancient Egyptians believed they needed servants in the afterlife, most of them thought they could get the assistance they needed from small figurines – called ushabtis – that were placed in their tombs.

Perhaps some nobles chose to also have their real servants buried nearby as a contingency – although at the moment, we don't know for sure. "A lot of explanations are possible," says Schrader. ▮

Palaeontology

Early mammals had dull fur to prevent them being eaten

Michael Le Page

WHILE many dinosaurs and pterosaurs flaunted flamboyant feathers, early mammals had greyish-brown fur.

"They were dinosaur food," says Matthew Shawkey at Ghent University in Belgium. "You didn't want to be conspicuous."

Since the 1990s, thousands of fossils with feathers and fur have been discovered. In some cases, traces of melanosomes – cell organelles that contain the pigment melanin – can be seen when fossils are examined under a microscope.

Melanin comes in two variants – black-brown and yellow-red – and the shape of melanosomes varies according to their composition. So, knowing the shape of melanosomes in fur or feathers gives you a good idea of their colour.

Shawkey's team first looked at the melanosomes in the fur of a range of 116 living mammals. From this, they developed a model that predicts fur colour based on melanosome shape and applied this to six fossils of different early mammals (*Science*, doi.org/pbqn).

All six fossils came from the same deposits in China, but the species lived at different times ranging from the Middle Jurassic to the Early Cretaceous, around 165 million to 120 million years ago. One of them was a newly described gliding mammal named *Arboroharamiya fuscus* that lived around 159 million years ago. These mammals are all thought to have been nocturnal, so it is no surprise they were all rather plain.

"The one thing I was surprised by is how invariant they were. The colours were even more similar than I would have predicted," says Shawkey.

It was only after the extinction of the dinosaurs that many mammals became active in the daytime and that is probably when their colours became more diverse, he says. ▮

Solar system

Giant rocks roll on surface of Titan

The wind on Saturn's largest moon could make things tricky for an upcoming NASA mission

James Woodford

NASA's Dragonfly mission is due to land on Titan in 2034, flying to dozens of locations across the surface of Saturn's largest moon to study its potential for habitability, but along the way it may also have to dodge wind-driven rolling boulders of up to half a metre in diameter.

The mission, which will launch in 2028, includes a "rotorcraft" that will explore the moon from the skies.

We have had only one up-close glimpse at Titan, thanks to the Cassini orbiter and Huygens probe, which reached the surface in 2005.

That mission revealed fields of rounded boulders as well as radar-bright plains with streak-like features thought to be windblown ice grains, suggesting that wind plays a key role in sculpting the moon.

To learn more, John Marshall and Lori Fenton at the SETI Institute in Mountain View, California, modelled what kind of windy conditions Dragonfly may encounter when it arrives on the surface.

They found that rocks could be blown relatively easily around on Titan's surface, "rather similar to a landscape with tumbleweeds, albeit somewhat less energetic", says Marshall.

Marshall says the ability of nature to move something with wind or water is a function of three factors: local gravity (less gravity equals less weight); the density of the object being moved (low-density materials are easier to lift); and the density of the air and liquid (dense liquids have more "push").

The pair based their calculations on Titan's rocks being less dense than rocks on Earth – 900 kilograms per cubic metre, composed of tholin and ice, compared with silicate rocks on Earth, which are about 2700 kilograms per cubic metre.

"If you combine these three factors," says Marshall, "you can estimate the potential for moving stuff around. The potential for Titan's wind to mobilise material is 80 times that on Earth."

NASA/JH APL/STEVE GRIBBEN

An artist's impression of NASA'S Dragonfly rotorcraft-lander on the surface of Titan

"The math indicated that relatively large ice stones could, in theory at least, be roaming around on Titan's surface," he says – perhaps ones up to half a metre in diameter (*Planetary and Space Science*, doi.org/pbqv).

"I think they have put a very nice case that it needs to be considered as a process on Titan's surface and it will need to be factored in for the planning around the Dragonfly mission," says Helen Maynard-Casely at ANSTO in Sydney, Australia.

Huygens only briefly measured winds on Titan's surface and found them to be quite weak – 0.01 metres per second – compared with the new calculations.

"But if you sent a probe to Earth, not knowing what its winds were like, and landed on a calm day in Fairbanks, you wouldn't extrapolate that to describe winds in Johannesburg or Kuala Lumpur," says Fenton.

So what does that mean for keeping Dragonfly safe from any rolling boulders? Fenton and Marshall say it should avoid landing near any perched, rounded stones.

"Dragonfly will have cameras to identify safe landing areas, so it can easily avoid any such stones," says Fenton. ▮

Psychology

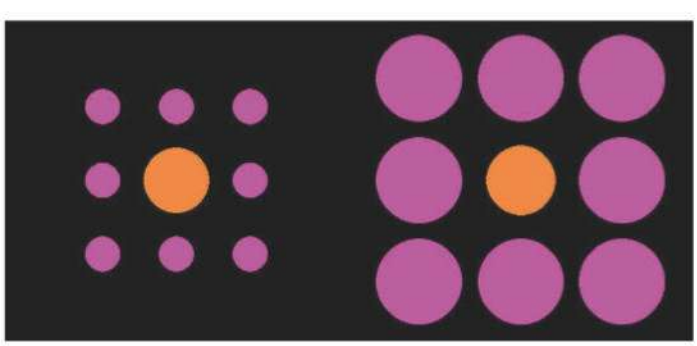
You could train your brain to be less easily tricked by illusions

OPTICAL illusions can make you feel like a fool, but you may be able to learn how to resist them.

"It is very likely that people from the general population have the capacity to be trained to unsee illusions and perceive the world more objectively," says Radoslaw Wincza at Lancaster University, UK.

Wincza and his colleagues recruited 44 radiologists who had spent more than a decade spotting small details such as fractures in medical scans. They also looked at 107 university students.

Each participant was shown four illusions on a screen, one at a time.



RADOSLAW WINCZA ET AL. (2025)

Did you spot that the orange circle on the left is smaller than the one on the right?

In each illusion, the participant saw pairs of shapes or lines of slightly different sizes or lengths, and had to select the larger or longer one.

In three of the illusions, other objects made the larger shape or longer line appear to be the smaller or shorter one. The team found that radiologists were less susceptible to these illusions than the students (*Scientific Reports*, doi.org/pbqt).

"Radiologists have this ability to really focus on the key elements of the visual scene," says Wincza. "By better tuning into the target, they don't experience the illusion as much."

In the fourth illusion, one of the shapes was vertical, while its pair was horizontal. This made the latter appear wider, even though it was actually narrower. Both groups were equally susceptible. That is probably because this one didn't include any surrounding objects, so it was less about tuning out background distractions, which radiologists may be well-practised at, says Wincza.

"It suggests anyone can gain that ability to be less susceptible to illusions if they train themselves," says Karla Evans at the University of York, UK. For instance, focusing on specific aspects of a picture might improve this ability, she says. ▮

Carissa Wong

Human evolution

Face bones hint at first humans in Europe

Michael Marshall

BONE fragments from a Spanish cave are part of the oldest human face ever found in western Europe. The bones are from the cheek and upper jaw, and are between 1.1 million and 1.4 million years old.

The bones are substantially different from the next oldest hominin bones from the same area, suggesting two distinct groups of ancient humans lived in western Europe around a million years ago.

"This paper introduces a new actor in the story of human evolution in Europe," says Rosa Huguet at the Catalan Institute of Human Paleoecology and Social Evolution (IPHES-CERCA) in Tarragona, Spain.

The bones were found in a cave called Sima del Elefante in the Atapuerca region of northern Spain. In 2008, a lower jawbone was found in the cave and dated to 1.1 million to 1.2 million years ago.

Researchers led by Huguet continued excavating in the cave, and in 2022 they found a few pieces of hominin bone. When the team pieced them together, they turned out to be from the left side of the face: part of the cheekbone and part of the upper jaw, including pieces of the first two molar teeth (*Nature*, doi.org/pbjc).

In the same layer, the team found three stone artefacts: a cobble tool made of quartz, and flakes of quartz and chert. They are Oldowan tools, which are "not very complex", says Xosé Pedro Rodríguez-Álvarez, also at IPHES-CERCA.

The new bones were discovered 2 metres deeper than the earlier jawbone. However, the team found the surrounding sediments were 1.1 million to 1.4 million years old – which is indistinguishable from the age of the jawbone. For this reason, "we think that it is the same species", says José María Bermúdez de Castro at the National Research Center on Human Evolution (CENIEH) in Burgos, Spain.

Because they have so few bones, the researchers have decided not to make a firm claim about the species. They have assigned the bones to *Homo aff. erectus* – meaning they could be *Homo erectus* but they aren't sure. "We cannot be conclusive in assigning it or ruling it out," says María Martinón-Torres, also at CENIEH. "It may also belong to an entirely different species."

"They are appropriately cautious," says Brian Villmoare at the University of Nevada, Las Vegas. We have very few *H. erectus* faces, he says, so we don't know how much they varied.

The bones of another hominin – dubbed *Homo antecessor* – were found in the Gran Dolina cave in the Atapuerca region, and have been dated to 772,000 to 949,000 years ago. *H. antecessor* faces are quite different from those of *H. aff. erectus*. "A species possibly related to *Homo erectus* would have given way to *Homo antecessor*," says Bermúdez de Castro. ▮

MARIA D. GUILLÉN / IPHES-CERCA

This jaw fragment is from the earliest face found in western Europe

Space

Asteroid Bennu is even stranger than we thought

Alex Wilkins

THE asteroid Bennu is puzzling scientists, with samples from the space rock showing weird properties.

When NASA's OSIRIS-REx spacecraft returned samples from the asteroid to Earth in 2023, scientists quickly found these contained a plethora of the chemical building blocks for life, including particles rich in phosphorus and nitrogen-containing carbon compounds.

"Bennu would literally race across the vial and climb up the side when a magnet was applied"

Zack Gainsforth at the University of California, Berkeley, and his colleagues looked at some of these particles using an electron microscope and found improbably high amounts of nitrogen. This included a compound containing carbon, oxygen and nitrogen with an "insane" amount of almost 20 per cent nitrogen, he says.

A separate team looked at the structures some of these carbon compounds formed. Many asteroids have nanoglobules, which are tiny, hollow blobs of carbon that can contain other important molecules within them. But in Bennu, these nanoglobules appeared to stick together to form vast structures hundreds of times larger, called macromolecules. "You could see these things with the naked eye in the microscope," says Simon Clemett at NASA's Johnson Space Center in Texas.

When Clemett and his team analysed these macromolecules, they found chemical hints that they had formed in extremely cold environments around the time the sun formed – 4.5 billion years ago – or even earlier, and have stuck together ever since.

These macromolecules might have acted as a protective bubble around important elements for life, shielding them from the solar system's harsh environments and later delivering them to a forming planet. "It's a good delivery mechanism," says Clemett. But how they stuck together is still a mystery, he says.

Bennu's weirdness doesn't stop there. While George Cody at the Carnegie Institution for Science in Washington DC and his colleagues were preparing samples for analysis, the researchers noticed the samples responded extremely strongly to magnetic fields.

"I have never seen anything so magnetic in my entire life," Cody told the Lunar and Planetary Science Conference in Texas on 10 March, where all three studies were presented. "I had some crushed Murchison [an Australian meteorite] and some crushed Bennu, and I took a big magnet up to the vials and held them there. Murchison just sits there, even though it has a lot of magnetite and [other magnetic compounds], but Bennu would literally race across the vial and climb up the side."

He says the samples were being prepared for nuclear magnetic resonance, and that it is possible that the strong magnet may have magnetised the particles. But he adds that he hasn't seen this effect with 35 other meteorites he has analysed in a similar manner.

Cody says that he and his team are still working to figure out how Bennu came to acquire its magnetic properties. ▮

Climate change

Can forests soak up our extra CO_2?

A patch of old oak trees in the UK is helping scientists predict how the world's forests will respond to higher levels of carbon dioxide, finds **Madeleine Cuff**

TUCKED down a quiet country lane in the UK's West Midlands region lies one of the most studied patches of forest in the world.

This fragment of woodland, populated mainly by 180-year-old English oak trees (*Quercus robur*), is at the heart of a global project to understand how the world's forests will cope as levels of carbon dioxide rise in the atmosphere.

It is a crucial question. Globally, forests absorb around 7.6 billion tonnes of CO_2 per year, once forest-related emissions from things like wildfires are taken into account. Temperate forests, such as those in the UK, account for almost half of that uptake.

But can we rely on this carbon sink as pollution increases? By 2050, atmospheric concentrations of CO_2 will be 40 per cent higher than today's levels if current trends continue, at roughly 570 parts per million (ppm).

At the forest in Staffordshire, mature oaks have been subjected to a simulated future atmosphere. Since 2017, CO_2 has been pumped around these trees, elevating local concentrations to 570 ppm.

Rob MacKenzie at the UK's University of Birmingham, which runs the site, has been watching to see how the trees respond. In principle, with higher levels of CO_2, the rate of photosynthesis increases. In other words, trees and plants will respond to more CO_2 in the atmosphere by drawing down more of it. Experiments on young trees have borne that out. But until recently, we knew little about how more mature trees would respond.

"The way that a young plant in a greenhouse or an agricultural field will respond over a short period, that's quite well known," says MacKenzie. "But how an older plant sitting in its soil for 180 years will respond to a similar stimulus is completely unknown."

SHOMARI HEALY

Mature oaks in this forest experience carbon dioxide levels that may occur in 2050

Finding out will be critical for ensuring that climate models accurately represent forests. If the photosynthesis rate changes and the trees absorb more carbon, the global carbon drawdown rate of temperate forests will increase. But if the carbon uptake rate doesn't change, the role of forests as a climate solution will be smaller than we thought.

Thankfully, the results so far are promising. After seven years under elevated CO_2 conditions, the mature oaks have increased their photosynthesis rate and are producing about 11 per cent more wood each year, compared with nearby trees under today's atmospheric conditions.

"After seven years under elevated CO_2 conditions, the oaks produce 11 per cent more wood each year"

"We're pleased by the results because they don't show a forest that is going to fall over, ecologically speaking, under this kind of stress. It does seem like there is some adaptive capability here," says MacKenzie. "It might be the case that even as we go into a high-CO_2 atmosphere, the land carbon sink maintains its current role in slightly bending the curve [of atmospheric CO_2]."

Yet a similar experiment on a mature eucalyptus forest in Australia, which also began in 2017, has found no link between elevated atmospheric CO_2 and extra tree growth.

The reason for this difference lies in the availability of nitrogen and phosphorus, key nutrients that enable trees to make use of excess CO_2. In Australia, the forest was limited by a lack of nutrients, but the Staffordshire site has plenty – thanks in part to the use of fertiliser on nearby farmland. "Everything about the results we have got so far is really down to the fact that the forest has sufficient nitrogen to utilise the carbon," says MacKenzie.

There is also emerging evidence that the mature oaks are deploying new strategies to secure their supplies of nitrogen. They are growing new root networks at a rapid pace and conserving their supplies by releasing less nitrogen through their roots and leaves, the team has found. "These strategies have enabled this forest not to exhibit any sign of nitrogen limitation," says Sami Ullah, also at the University of Birmingham.

It represents a remarkable shift in activity for middle-aged trees, says MacKenzie. "They have had 180 years to explore the soil," he says. "You might well hypothesise that the soil is completely mapped from the plant's perspective. But it turns out there are still things they can do if the resource changes."

But sustaining this activity depends on nitrogen remaining plentiful. In previous elevated CO_2 experiments performed on young trees, nitrogen supplies eventually dwindled, leading to a slump in the photosynthesis rate. "If the trees are using more nitrogen, they are going to eventually deplete the soil of nitrogen," says Anna Gardner, also at the University of Birmingham. "It's a positive story for us so far, but in the long term we are not sure."

The Staffordshire experiment will keep going until 2030, at which point the researchers hope to have unpicked the effects of nitrogen limitation.

In any case, wood is only ever a temporary carbon store. Even if trees survive climate change's growing threats of droughts, heatwaves, floods, pests and diseases, they will eventually die. As the wood rots, the stored carbon is released back into the atmosphere.

It would be foolish to rely too heavily on forests as a climate saviour, even if their increased photosynthesis rate is sustained, says MacKenzie. "It's only a help; it's not a solution." ▮

Health

A selfish reason to give blood

People who regularly donate blood may see a boost in the growth of healthy blood cells

Carissa Wong

FREQUENT blood donors might be getting more than a warm, fuzzy feeling from their altruism, as giving blood may also enhance your ability to produce healthy blood cells, potentially reducing the risk of developing blood cancer.

Hector Huerga Encabo at the Francis Crick Institute in London and his colleagues analysed genetic data extracted from blood cells donated by 217 men in Germany, aged between 60 and 72, who had each given blood more than 100 times. They also looked at samples from 212 men of a similar age who had donated blood fewer than 10 times each, and found that frequent donors were more likely to have blood cells carrying certain mutations in a gene called *DNMT3A*.

To understand this difference, the team genetically engineered human blood stem cells – which give rise to all blood cells in the body – with these mutations and added them to lab dishes along with unmodified cells. To mimic the effects of blood donation, they also added a hormone called EPO, which the body produces following blood loss, to some of the dishes.

A month later, the cells with the frequent-donor mutations had grown 50 per cent faster than those without the mutations, but only in the dishes containing EPO.

Blood donors could be getting a health kick from their actions

SCOTT OLSON/GETTY IMAGES

Without this hormone, both cell types grew at a similar rate (*Blood*, doi.org/g87vrw).

"It suggests that, every blood donation, you're going to have a burst of EPO in your system," says Encabo, "and this is going to favour the growth of cells with these *DNMT3A* mutations."

To investigate whether having more of these mutated blood cells is beneficial, the team mixed them with cells carrying mutations that raise the risk of leukaemia, and again found that, in the presence of EPO, the frequent-donor cells substantially outgrew the others and were better able to produce red blood cells. This suggests that the *DNMT3A* mutations might suppress the growth of cancerous cells, says Encabo.

"It's like the donation of blood is providing a selection pressure to enhance the fitness of your stem cells and their ability to replenish," says Ash Toye at the University of Bristol, UK. "Not only could you save someone's life, but maybe you are enhancing the fitness of your blood system."

Further work is needed, says Marc Mansour at University College London, as lab experiments are a simplified picture of what happens in the body. "This needs to be validated in a much larger cohort, across different ethnicities, across females and other age groups," he says. He also points out that donors without these mutations in *DNMT3A* may not see this benefit. ▮

Chemistry

Metals squeezed into sheets just a few atoms thick

SHEETS of metal that are as thin as chemically possible can be produced by squashing molten droplets at great pressure between two sapphires. The unusual materials could have applications in industrial chemistry, optics and computers.

Last year, scientists created a gold sheet that was a single atom thick, which they dubbed "goldene" after graphene, a material made of a single layer of carbon atoms. Such materials have been described as two-dimensional, because it isn't possible for them to be any thinner.

But making other 2D metals hadn't been achievable until now. The new technique, developed by Luojun Du at the Chinese Academy of Sciences and his colleagues, can create 2D sheets of bismuth, gallium, indium, tin and lead that are as thin as chemically possible.

To squeeze the metal, they used two extremely flat sapphire crystals with a thin layer of molybdenum disulphide (MoS_2) as the jaws of a vice. They placed the powdered metal between these jaws, heated it up to 400°C until it formed a droplet, then crushed it at an enormous pressure of up to 200 megapascals. The metal was compressed until it was a few atoms thick – or, for bismuth, just two – then allowed to cool. When the pressure was removed, the 2D metal was sandwiched between the MoS_2 sheets, which then slipped away from the sapphires (*Nature*, doi.org/g876n5).

Du says the process was conceived eight years ago, but only bore fruit when they discovered that the MoS_2 layers kept the thin metal sheets stable. "A single layer of free-standing metal atoms is simply unstable from a thermodynamic point of view. Therefore, we [had to] develop entirely new techniques," says Du. "The process seems simple, but it works."

400°C

The temperature to which the metal was heated before it was squeezed

The researchers were able to fine-tune the squeezing pressure and make metal plates three, four or more atoms thick with precision.

2D metals could have unusual properties that help scientists explore macroscopic quantum phenomena and superconductivity, says Du, and may lead to ultra-low power transistors, transparent displays for computers and extremely efficient catalysts for chemical reactions. ▮

Matthew Sparkes

Mind

How to have a good day, according to science

Elizabeth Hlavinka

WE MAY finally know what constitutes a good day – and it can even involve commuting.

Dunigan Folk at the University of British Columbia in Canada and his colleagues wanted to distinguish what separates a good day from an average one. They used machine learning to analyse data from the 2013 and 2021 American Time Use Survey, which measured the time thousands of people spent doing more than 100 activities.

The team then corresponded the activity times with whether the participants reported their day as being better than typical.

General socialising for more than 30 minutes was one of the most important activities for a good day, but had little additional benefit beyond 2 hours. Yet spending time with friends specifically had "an almost boundlessly positive effect", the researchers write.

The impact of working was also time dependent: doing so for up to 6 hours had no impact on whether a day was good or not, but any longer and things rapidly turned negative. Perhaps surprisingly, commutes of no more than 15 minutes were associated with having a good day in 2021, but not 2013, "potentially because there may have been emotional benefits from getting out of the house during the covid-19 pandemic", they write (PsyArXiv, doi.org/pbsp).

Sonja Lyubomirsky at the University of California, Riverside, says there could be other factors they didn't measure that explain the relationship between, say, time spent working and the quality of a day. "Having said that, these findings are totally aligned with the experimental data that show when you ask people to socialise more [with loved ones], they report greater happiness and improved mood and improved connection," she says. ▮

Zoology

Wildlife under threat as bird flu reaches Antarctica

Michael Le Page

H5N1 bird flu has been found in dead birds on Antarctica for the first time. The deadly strain of bird flu is currently spreading south along the Antarctic Peninsula and could spread around the continent, with devastating consequences for wildlife such as penguins.

"It's scary. Fortunately, it's affecting just a few [birds]," says Juliana Vianna at the Pontifical Catholic University of Chile in Santiago. "I hope it stays that way, but avian flu in Chile and Peru was a disaster. It killed thousands and thousands of seabirds and sea lions."

Between November 2024 and January 2025, Vianna's team surveyed 16 nesting sites of seabirds along the Antarctic Peninsula. The researchers found 35 dead skuas that had no signs of injury. Samples from 11 of the bodies were found to be positive for the highly pathogenic H5N1 bird flu virus that has been spreading around the world in recent years (*bioRxiv*, doi.org/pbh7).

Adélie penguins in Antarctica are now at risk of bird flu

FRANCO BANFI/BIOSPHOTO/ALAMY

Skuas scavenge on corpses and predate on other birds, so they are particularly likely to become infected by feeding on infected animals. The skuas in this area are hybrids between south polar skuas (*Stercorarius maccormicki*) and brown skuas(*Stercorarius antarcticus*).

So far there are no confirmed cases in other bird species there, but Vianna says she was told on 9 March that dead penguins have now been found, too. "We just talked to the Chilean Antarctic Institute," she says. "They saw dead skuas and penguins."

"Because penguins breed in dense colonies, H5N1 could spread among them rapidly"

Because penguins breed in dense colonies, H5N1 could spread among them rapidly and kill off a large proportion of some populations, many of which are already in decline because of climate change. The susceptibility of birds to H5N1 varies from species to species, however, so some penguins may be resistant, says Vianna.

This highly pathogenic form of bird flu has been circulating in Europe, Asia and Africa since 2020. In 2021, it reached North America, and by the end of 2022, it had spread to the southern tip of South America.

Sick brown skuas and giant petrels on Bird Island, just off the larger Atlantic island of South Georgia, tested positive for the virus in 2023. South Georgia is around 1500 kilometres from the Antarctic Peninsula.

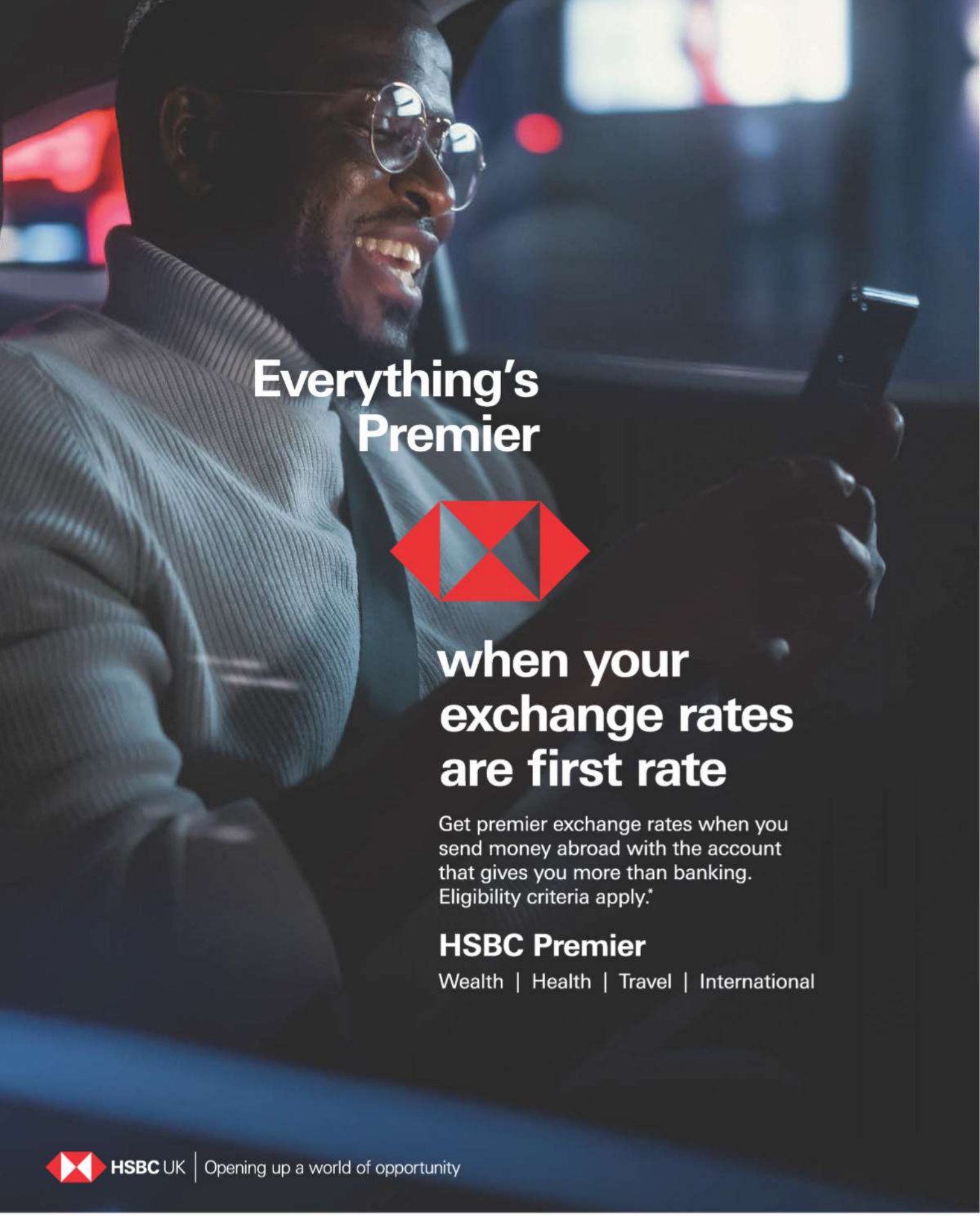
In December 2023 and January 2024, Vianna's team found signs of infection in some living Adélie penguins and Antarctic shags on the northernmost tip of the peninsula. Now the presence of the virus on the continent has been confirmed.

"The reported deaths of skuas is concerning," says Thijs Kuiken at Erasmus University Rotterdam in the Netherlands.

However, the tests described in Vianna's study show only that the skuas were infected with H5 flu, Kuiken says, not whether it was the highly pathogenic H5N1 form.

That is correct, says Vianna, but samples were sent off for additional testing not detailed in the paper. "So it is confirmed as highly pathogenic avian influenza," she says.

On 25 February, another group of researchers reported that they had found H5N1 on the archipelagos of Crozet and Kerguelen in the Indian Ocean near Antarctica, where the virus has killed elephant seals as well as several bird species. That means the virus has moved more than halfway around the Antarctic, towards Australia and New Zealand – the only major countries that remain free of H5N1. ▮


Everything's Premier
when your exchange rates are first rate
Get premier exchange rates when you send money abroad with the account that gives you more than banking. Eligibility criteria apply.*
HSBC Premier
Wealth | Health | Travel | International
HSBC UK | Opening up a world of opportunity

*Qualify for Premier with £100,000+ individual annual income paid to your account or £100,000+ savings or investments with HSBC UK, or Premier status abroad.

Issued by HSBC UK Bank plc, 1 Centenary Square, Birmingham, B1 1HQ, United Kingdom. ©HSBC Group 2025. All Rights Reserved. AC66634

CURRENT ACCOUNT SWITCH GUARANTEE

Views

The columnist
Chanda Prescod-Weinstein on a high-energy neutrino p22

Aperture
Cuneiform tablets bring Mesopotamia back to life p24

Culture
Fight fake news with a great guide to the nature of proof p26

Culture columnist
Emily H. Wilson enjoys a terrific book on robot rights p28

Letters
How worried do we need to be about mirror life? p29

Comment

No crystal ball needed

Creating an early-warning system for climate "tipping points" is wrong on so many levels it is hard to know where to begin, says **Bill McGuire**

SCIENCE funding is rarely a bad thing, and when it goes towards boosting our knowledge of the greatest threat to humanity, it has to be seen as a positive. So, the £81 million slated recently by the UK Advanced Research & Invention Agency to improve understanding of highly dangerous climate "tipping points" is most welcome. The manner in which the giveaway is framed, however, really isn't.

According to the agency, the funding will support the creation of an early-warning system (EWS) that will "confidently predict when a system will tip", alongside pinning down the timing of the tipping and the consequences.

This is wrong on so many levels it is hard to know where to begin. For a start, if such an EWS were to work, we would need to be certain that the tipping points in question – in this case the focus will be primarily on the Greenland ice sheet and the system of ocean currents known as the Atlantic Meridional Overturning Circulation (AMOC) – hadn't already been crossed. As the minimum global average temperature rise at which either might undergo irreversible change has been estimated at 1°C or less, we cannot be sure this is the case.

It could also be argued that there are already early-warning signs for all to see. In the case of the AMOC, this is the "cold blob" south of Greenland arising from higher ice melt reducing ocean salinity, and elevated temperatures along the eastern seaboard of North America, caused by a backing up of the AMOC as its strength fades. With the Greenland ice sheet, the loss of 6 trillion tonnes of ice since the early 1990s should be enough to drive urgent action without further warning. Even if a climate system hasn't yet tipped, by the time enough data is gathered to determine whether or when tipping might happen, it is likely to be too late to stop it.

ELAINE KNOX

And there's more. Having worked to develop more than one EWS to anticipate and help tackle volcanic crises, I know they are useless on their own. Even if we identify the timing of a tipping point and have better pinned down the consequences, what then? An EWS is only one element of an emergency management plan that must also encompass mitigation (if feasible) and response. For a volcano, this can be building barriers to divert lava flows and evacuation of areas most at risk, followed – if needs be – by a general evacuation.

The existence of a tipping point EWS also gives the impression that no action is needed until an alarm sounds, which is short-sighted and dangerous. With climate tipping points, the most critical part of emergency management actually precedes any early warning, as the only really effective mitigation is to prevent tipping. This requires global emissions to be slashed by at least 50 per cent within five years, and even this is no guarantee of keeping the Greenland ice sheet largely intact or the AMOC circulating in a near-normal state. In addition, governments should be making plans now for how society will handle the consequences of tipped climate systems, and for the mayhem that already locked-in climate breakdown is set to bring. This isn't happening.

The truth is that a climate EWS has been ringing for decades, and every extreme weather event – every Los Angeles wildfire, every Valencia deluge – ratchets up the noise by a few decibels. However, it seems that, despite the constant ringing, we just aren't listening. Emissions continue to climb, fossil fuel corporations plan for expansion and governments turn away from green measures.

Maybe the reality of actually crossing a key climate tipping point will be like having a bucket of freezing water poured over our heads and will finally wake us up to what is happening. By then, of course, it will be too late. ▮

Bill McGuire's next book, *The Fate of the World: How our future is written in the past*, is out next year

Field notes from space-time

Full of energy

Last month's discovery of a record-breaking neutrino is incredibly exciting for us particle physicists – but it also raises many questions, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

Chanda's week

What I'm reading
I have been enjoying Never Say You Can't Survive: How to get through hard times by making up stories *by Charlie Jane Anders.*

What I'm watching
For the first time, I am viewing every episode of The Golden Girls.

What I'm working on
During these hard times, I am trying to stay in touch with my sense of wonder and possibility.

This column appears monthly. Up next week: Graham Lawton

IF YOU have ever eaten a banana, then you have consumed an active radiation source. They are rich in potassium, a small fraction of which is the naturally occurring radioactive isotope ^{40}K (potassium-40). While this might sound scary, the levels are safe for human consumption, and they have a fun side effect: neutrinos. Beta decay, one of the ways unstable atoms can undergo radioactive decay, converts the potassium into calcium with a side helping of elementary particles: an electron and a neutrino.

Sometimes referred to as "ghost particles", neutrinos are actually cousins of the electron. Just like electrons, they are elementary particles that can't be broken into smaller parts. Their intrinsic, quantum sense of rotation has the same value as the electron's. There are fundamental differences, though. While electrons have an electrical charge and hence interact strongly with matter, neutrinos don't and are said to be ghost-like because they interact with almost nothing. While you have been reading this, about 6000 trillion neutrinos passed through your body. None stopped to hang out, though, because we are essentially invisible to them.

Although every electron in the universe is identical to every other electron, neutrinos come in three flavours: the electron neutrino, the muon neutrino and the tau neutrino. Neutrinos also differ from electrons in another way: we understand a lot less about them. Explaining how they get mass remains a major mystery in particle physics. We aren't even sure what their masses are, except that they are very small – so small that, for a while, we wondered if they were completely massless, which would mean they were capable of travelling at the speed of light. We know now that while they can get close to this maximum speed, they are slowed by a wee bit of mass.

But this isn't the most amazing feature of neutrino behaviour as they move through space. Neutrinos are deeply unusual because their identities may change as they mature. An electron neutrino doesn't necessarily remain an electron neutrino; it may at some point become a muon or tau-type instead. In other words, neutrinos are non-trinary, oscillating between and mixing three possible identities. We particle physicists think that this non-trinaryness is somehow related to how neutrinos get their mass, but we still aren't sure.

> **"The neutrino's birthplace was probably near an extremely massive black hole actively accreting material"**

Neutrinos may be a mystery in their own right, but they can give us an insight into other cosmic questions. In fact, neutrinos have become an important alternative to photons for observing the cosmos because phenomena like stars, black hole accretion discs and supernovae emit them.

The search for these cosmic neutrinos occasionally yields very exciting results. Last month, scientists at the European Cubic Kilometre Neutrino Telescope (KM3NeT) announced they had seen evidence of a 220 peta-electronvolt (PeV) neutrino, the most energetic one anyone has detected. An energy this high is comparable with the energetic environment around a neutron star, which is the second most compact type of object in the universe, after a black hole. By contrast, past measurements of neutrinos "only" came in at around 10 PeV. This new one is 20 times more energetic.

KM3NeT didn't capture the neutrino directly, since, as I mentioned, these particles are hard to get our hands on. Instead, the telescope's detector captured a very energetic muon, another elementary particle. Using our understanding of the theory behind neutrino and muon interactions, researchers were able to reconstruct the muon's path. The most likely scenario is that the muon was created by a 220 PeV neutrino colliding with some other elementary particle.

The discovery raises new questions. Because the neutrino was unusually energetic, it may have a different origin story than other cosmic neutrinos we have seen. There are very few cosmic environments that create the conditions for such energy levels, which suggests that the neutrino's birthplace was in the vicinity of a particularly massive black hole with a very active accretion disc.

One of the delightful aspects of KM3NeT's discovery is that it creates the possibility neutrinos will help us get information about these extremely massive black holes, while also validating a 30-year-old proposal that such black holes could be used to better understand the non-trinary nature of neutrinos. This is a reminder that science can be a slow burn, requiring patience and persistence, while neutrinos are a reminder that identity transitions are a natural phenomenon. And the mystery around how and why these transitions occur helps us appreciate that the universe remains full of opportunity to better understand reality, when we are open to all the possibilities. ▮

Why we love the rain in Yorkshire

Taylor's brewery sits upon The Knowle Spring, the unique source of water we use to brew our beers. This particularly pure and consistent spring water is one of the reasons we're able to brew beer of such reliable quality and taste. It has filtered over time through layers of sandstone and black rock, which creates the special mineral qualities that marry perfectly with our Golden Promise barley malt. This unique combination is the foundation of the complex flavour and subtlety of Landlord. And it all begins with rain falling upon the Yorkshire hills. That's why we're always happiest when it pours.

All for that taste of Taylor's

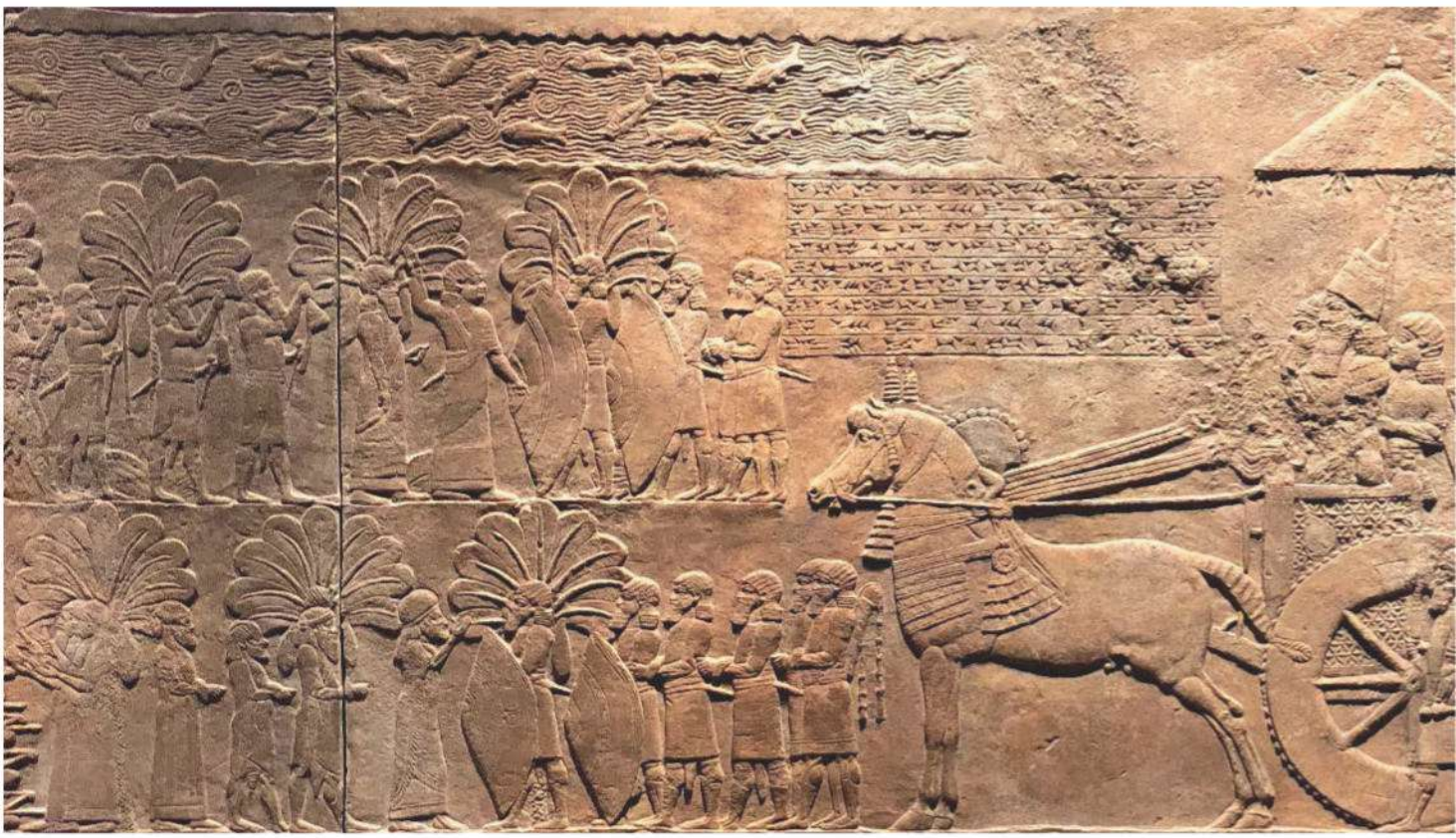
TIMOTHY TAYLOR'S LANDLORD
THE CLASSIC PALE ALE ABV 4.3%

GALAXY ON GLASS

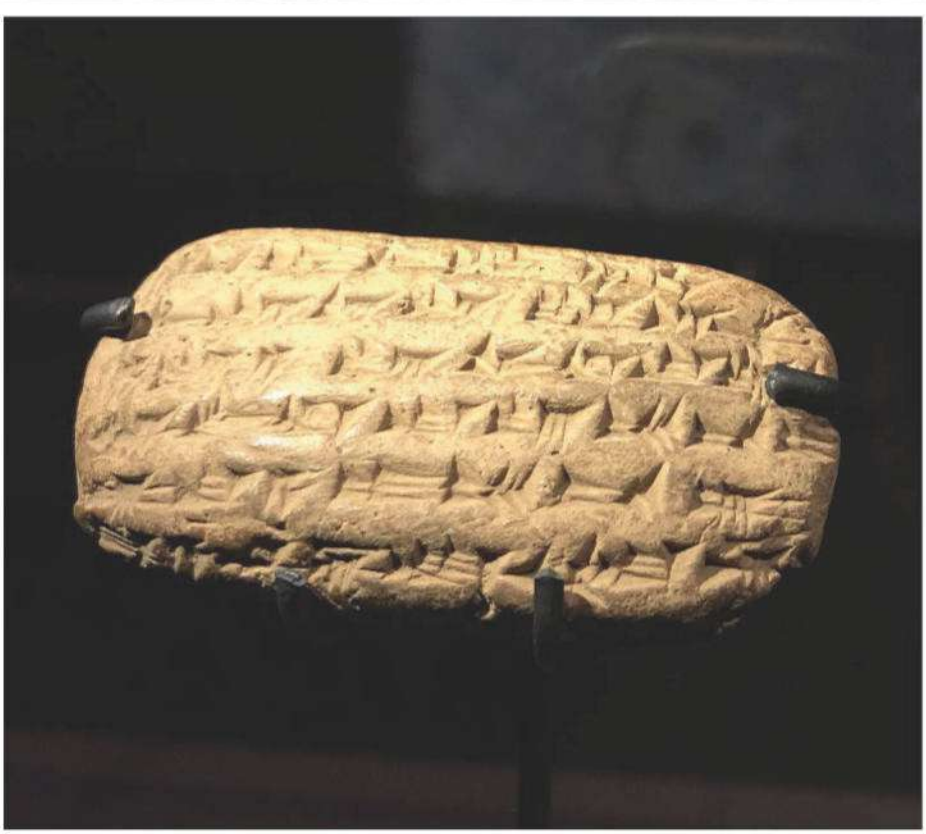
SPECTACULAR WALL ART FROM ASTROPHOTOGRAPHER CHRIS BAKER

Special Offer this month
20% Discount!
Use the code READER25
on check out

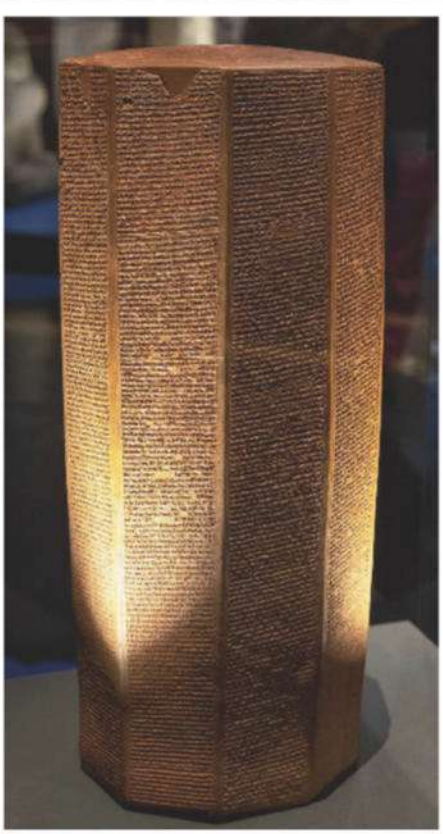
www.galaxyonglass.com
chris@galaxyonglass.com
+44 (0)7814 181647



BRITISH MUSEUM/AUDAY HUSSEIN



AUDAY HUSSEIN



ANTHONY HUAN/CC BY-SA 2.0

CAMRYN GOOD

BRITISH MUSEUM/CAMRYN GOOD

Clay lore

Allen Lane

IT IS one of the oldest and greatest stores of knowledge: a vast library of texts amassed by Assyrian King Ashurbanipal, who ruled ancient Mesopotamia about 2700 years ago. But after his death, it was ransacked and burned to the ground. Luckily, the texts were written on clay tablets, and so were baked and preserved by the heat.

When the ruins of the library were found in Victorian times in what is now Iraq, the astonishing richness of this lost world was revealed. A new book, *The Library of Ancient Wisdom* by Selena Wisnom at the University of Leicester, UK, pieces together a vivid portrait of Mesopotamian life from the shattered remnants of the 30,000 or so tablets in Ashurbanipal's library. Written in cuneiform, the world's oldest form of writing, the tablets not only bring kings and queens to life, but also priests, traders and professional lamenters. They also include magic spells and letters of complaint. Our lives are still influenced by ripples from this ancient world via the 60-minute hour, mathematical discoveries and the invention of the zodiac.

Clockwise from top, far left: a relief from Ashurbanipal's palace showing him in a chariot; a fragment of the *Epic of Gilgamesh*, telling the story of a great flood; the Royal Game of Ur board game, which Ashurbanipal enjoyed as a boy, according to letters by his brother; a clay prism with accounts of Ashurbanipal's military campaigns; and a letter in which his sister berates his wife for her poor cuneiform.

The Library of Ancient Wisdom is out now in the UK and will be published on 12 May in the US.

Alison George

Getting it right-ish

In a sea of fake news and misinformation, **Jacob Aron** welcomes a great guide to the nature of proof. But don't just take his word for it...

Book
Proof
Adam Kucharski
Profile Books (UK)
Basic Books (US, 6 May)

VLADEN ANTONOV/AFP VIA GETTY IMAGES

I HAVE something of a reputation as a party-pooper in the *New Scientist* office. At our weekly meeting to discuss the latest and greatest ideas in science, colleagues will eagerly describe some incredible new theory or spectacular find, then sit back to field questions. I can already hear the groans before I open my mouth to say: "Yes, but what is the actual evidence?"

I don't do this because I enjoy shooting down ideas (OK, maybe I do enjoy it a bit), but because, to me, determining whether something is true really is the point of science. You may have an idea so exquisite that it seems impossible for it to be anything but true, but if reality disagrees, then all you have is, at best, fan fiction. String theorists get angry when I point this out.

That said, the process of identifying truth is perhaps murkier than we often consider. What counts as evidence? Are some types of evidence more worthwhile than others? And to what extent should new evidence cause us to change our minds?

In his new book, *Proof: The uncertain science of certainty*, Adam Kucharski answers all these questions and more, reviewing the history of separating fact from fiction, while also offering advice on how you can personally figure out what is true in a sea of noise and misinformation. Let me see if I can apply some of his teachings to convince you that this is a book well worth your time.

First, there is the appeal to authority: Kucharski is a statistician and epidemiologist at the London School of Hygiene & Tropical Medicine, so you would expect him to know his stuff. But, as he explains, this is a pretty weak form of proof – you shouldn't take my word for it that the book is good just because I have been impressed by his credentials.

Stronger evidence comes from the observations I gathered while reading *Proof*. One of the first

"The process of identifying truth is perhaps murkier than we often consider. What counts as evidence?"

of many historical anecdotes in the book is about the Monty Hall problem, a thorny question of probability, first popularised in the 1990s. If you have read any popular science books in the past few decades, you will almost certainly have come across it, and I must have encountered the question dozens of times, leading me to worry that *Proof* would simply be rehashing old ground.

Thankfully, it seems this initial data point was an outlier. Kucharski digs up a number of stories I had never heard before, from Abraham Lincoln using Euclid's *Elements* to score political points, to the head brewer of Guinness creating one of the most important statistical tests still in use today. He also brings in his personal experience of the perils and pitfalls of modelling aspects of the covid-19 pandemic.

Ah, but we must remember that correlation is not causation. Just because my enjoyment of the book seems to be in line with Kucharski's excellent storytelling, that doesn't necessarily mean it was responsible. Perhaps, in order to gather stronger evidence, I should conduct a randomised controlled trial (RCT). I could assign half of the *New Scientist* staff to read *Proof*, while asking the other half to tackle a classic of the mathematical canon, something like *Fermat's Last Theorem* by Simon Singh, as a control group.

Maybe not. As Kucharski explains, while RCTs are often seen as the "gold standard" of evidence,

East Asian countries' longtime mask-wearing has value as evidence of their effectiveness

demanding them in all cases can hinder our efforts to uncover the truth. This became apparent during the covid-19 pandemic, particularly regarding mask-wearing, where any trials of their effectiveness, let alone RCTs, were hard to come by in the early days of the outbreak.

Sometimes, other forms of evidence – the fact that masks were already regularly used in East Asian countries to control infection, or arguments around the basic physics of respiration – have value, he writes.

This is, essentially, the book's underlying philosophy. "When dealing with complex questions and fragmented data, we can't necessarily rely on traditional one-study-one-answer approaches," writes Kucharski.

Proof is a great guide to embracing this complexity in truth-seeking – and if you don't believe me, go and read some other reviews, rather than relying on a single opinion.

Tune yourself up

Can you really change your personality? **Elle Hunt** enjoys the story of one woman who found out on a year-long experiment

Book

Me, But Better
Olga Khazan
John Murray (UK);
S&S/Simon Element (US)

From throwing a party to joining improv classes, how far would you go to change yourself?

MAYBE you would like to be more outgoing or organised. Or perhaps you want to worry less, or achieve more. It seems like everyone has something they would change about themselves if they could – some trait they would like to either possess or shed.

The self-help and wellness industries have successfully monetised that desire, promising if only we buy the right products and services, we might be transformed into new and better people. But is it possible to alter our personalities, or are we stuck with who we are?

That is the question US journalist Olga Khazan sets out to answer in *Me, But Better: The science and promise of personality change*, by experimenting on herself. In 2021, Khazan, a staffer at *The Atlantic* magazine, was assigned to spend three months trying to become, as she writes, less "neurotic, introverted, and disagreeable".

Having attempted to make new friends and dabbled in meditation and other experiments in "sociability, tranquillity and niceness", a test showed modest improvements in Khazan's extraversion and neuroticism – two of the "big five" personality traits, along with conscientiousness, openness and agreeableness.

For the book, Khazan extended her investigation, dedicating a year to self-improvement, this time with higher stakes. *Me, But Better* begins with Khazan as a self-described "high-strung misanthrope" debating both an interstate move and whether to become a parent. In the face of such personal upheaval, she reasons, it couldn't hurt to try to become more agreeable.

She is admirably frank (and often funny) about her personal deficiencies, such as her tendency to isolate herself from others, use alcohol to relieve stress and anxiety and fly off the handle at minor inconveniences. Even when she plays up her faults for comedic effect, Khazan is honest about their negative impact and unwavering in her commitment to change.

This combination of openness and conscientiousness – traits for which Khazan scored "very high" – elevates *Me, But Better* beyond self-help or stunt journalism. You believe she really does want to change – and is prepared to expend shoe leather in the attempt.

For her personality "tune-up", Khazan spends a few months at a time tackling each of the big five traits. To reduce her "extreme" neuroticism, she enrols in a mindfulness programme; to become more extroverted, she throws a party, joins an improv class and attends MeetUp events for like-minded strangers.

With her self-awareness and acerbic wit, Khazan is a winning narrator and guide through the frequently awkward process of self-improvement. The entertaining first-person set pieces are complemented with research and reporting, with dozens of expert interviews and case studies seamlessly integrated into the narrative. Khazan's light touch, despite the density and range of her material, is a testament to her confidence and skill as a journalist: she digs into the (relatively new) science of personality without ever sacrificing nuance or readability.

On the key question of whether it is possible to make personality changes that stick, Khazan comes to a hopeful conclusion. Between 30 and 50 per cent of personality may be attributable to genes, so we have some influence over the rest – and a lot of evidence supports faking it until you make it. "You just have to remember to act how you'd like to be, consistently," she writes.

A lesser author might have resorted to a limp message of self-acceptance. ▮

Elle Hunt is a writer based in Norwich, UK

MARTIN PARR/MAGNUM PHOTOS

New Scientist *recommends*

Rowan Hooper
Podcast editor
London

I am still digesting choreographer Wayne McGregor's latest work, **Deepstaria**, which debuted at London's Sadler's Wells recently before a tour. The piece is named after a genus

of deep-sea creature – mysterious, predatory yet delicate, and McGregor's favourite jellyfish.

The show's effects were sensational. The backdrop, for example, used Vantablack, a pigment meant to absorb 99.96 per cent of light, so the dancers could float into what looked like an abyss.

Once there, swirling movements and deft interactions helped them appear to defy not only gravity, but biology. I was astounded by how much they adopted the forms of marine invertebrates.

Nicolas Becker's soundtrack used a tool called Bronze AI to weave together the score with recordings of the marine ecosystem to create a "live" experience. I was absorbed into the plankton of the abyss and left the show mindful of the commonalities that all life forms share.

RAVI DEEPRES

The sci-fi column

Learning to live

Abigail has been created as a replacement for her owner's dead wife. But the law is about to change, granting her full human rights – what will she do? **Emily H. Wilson** explores the latest addition to "robo-rights" literature

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The second book in the series, *Gilgamesh*, is out now. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

GREMLIN/GETTY IMAGES

Granting Abigail human freedoms feels right even if she was made in a lab

WHILE the world grapples with the rights of regular humans versus artificial intelligence companies that want to mine both their data and their creative output, sci-fi is contending with rather different aspects of the future of AI. In fact, three books published over the past year have focused on the individual rights of AIs themselves in visions of near or near-ish futures where robots are common.

Last year, *Annie Bot* by Sierra Greer brilliantly examined the relationship between a sexbot (with no rights) and her icky owner. *Service Model* by Adrian Tchaikovsky had an abandoned service bot, Uncharles, wandering a dystopian world in search of purpose. Now we have *Some Body Like Me* by Lucy Lapinska, in which our heroine, Abigail, is a robot replica of her owner's dead wife (also called Abigail).

Abigail has been created from pictures, videos and husband David's memory of the original Abigail, right down to stretch marks, a knee scar and freckles. Much like Annie Bot, Abigail is a companion, housekeeper and sex toy with no rights at all, but here the household arrangement carries extra-creepy baggage given that Abigail is required to act like a woman she has never met.

The twist in *Some Body Like Me* (actually, one of the twists – the book has many) is that robots like Abigail are about to be fully emancipated. For now, their rights are zilch, but in days, they will be able to walk out of their owners' homes as free individuals.

> **"In this future, humans are dying of radiation poisoning and robots are positioned to fill their biological niche"**

This feels unquestionably right to us as readers. After all, Abigail is surely a living creature. She can respire, grow (even if it's only via new coding pathways), excrete, reproduce (if she learns to build more robots) and move, and she is responsive to her environment... all the normal markers of life, give or take. She is also, of course, highly intelligent. Yes, she has been coded to do and be all those things, and her skeleton has been designed in a lab. (She needs to take all her skin off to wash, by the way, which seems like a pretty bad design flaw to me.) But she comes across as someone who is not only alive, but a person, and a good one at that.

Actually, the set-up in the novel is bigger even than robots being given rights. Humans are dying of radiation poisoning in this vision of the future, and robots are positioned to fill their biological niche. They are also poised to do a rather better job of looking after the world, according to everything we see and hear in this book.

All this is exciting for Abigail, although nerve-wracking. What will she do with her life? Sadly, it is also an extremely dangerous time to be a robot... but I won't ruin the plot for you.

The first half of *Some Body Like Me* slipped down a treat. I was very slightly less keen on the second half, but that is probably because (being an insufferable prude) I was less interested in what Abigail the robot might enjoy in bed than perhaps another reader might be.

That aside, this is a terrific book and a worthy addition to the books examining our emerging relationship with AI. It also makes me look forward to whatever sci-fi does next in this arena.

In the years ahead, it will be interesting to see if regular humans (outside academia, I mean) start to ask whether the AIs mining our data, reading our work, writing our college essays and ruling over our social media feeds deserve some personal rights.

Book

Some Body Like Me
Lucy Lapinska
Gollancz
Out 17 April (UK)

Emily also recommends...

TV

Battlestar Galactica
Glen A. Larson and Ronald D. Moore
The ultimate TV show about robots. Despite the fact that the humanoid Cylons are engaged in the wholesale slaughter of billions of humans, the series does explore what the rights of Cylons might be. Because it's a great show! By the way, don't forget to begin with the 2003 miniseries.

Editor's pick

How worried do we need to be about mirror life?

1 March, p 34

From Sam Edge, Ringwood, Hampshire, UK

If we exclude the panspermia hypothesis, then life on Earth, with key biomolecules utilising only one of two possible mirror-image – or chiral – forms, arose from random "experiments" in which prebiotic molecules became self-replicating and able to adapt.

It seems unlikely that only a single instance survived to go on to create all life. If there were multiple instances, then, statistically, some must have had the opposite chirality.

That none of these endured suggests that something in that chirality made them less fit to spread, either due to biochemistry or because the chirality of observed life outperformed them. This implies that if we did manage to create "mirror life", it too would be less fit and would die out again without artificial support. In the long term, most life on Earth would be unaffected.

From John Kitchen, Kettering, Northamptonshire, UK

Assuming the chirality of life on Earth was randomly selected and locked in, the opposite chirality could have happened just as easily. We are now exploring other worlds and moons looking for life. What if we discover mirror bacteria on Saturn's moon Titan? Would it be safe to return samples to Earth? Would any hitchhiking bacteria from Earth destroy all life on Titan?

AI is finding a lot of uses in everyday life

Leader, 15 February

From Rollen D'Souza, Mississauga, Ontario, Canada

The idea that artificial intelligence has no "clear use case" is, in my opinion, disconnected from the facts. Many may feel that AI usage has negative consequences, but there are plenty of stories of people using it in effective ways.

My younger colleagues avoid Google. They use ChatGPT or its equivalents and complain that searching and even learning without AI is difficult, takes longer and yields worse outcomes. AI has made a tangible difference.

Long live the blue zones, global longevity hotspots

8 March, p 30

From Dan Buettner, blue zones discoverer, Miami Beach, Florida, US

Numerous peer-reviewed studies have validated the demographic origins of blue zones. The insights extracted from these longevity hotspots have created principles that have helped people live longer, healthier lives for a quarter-century. Claims to the contrary insult the science of demography and the people of blue zones, who are very proud of their culture of longevity.

Rewilding doesn't have to be a blow for other places

22 February, p 12

From Jonathan Spencer, visiting professor, school of geography, University of Southampton, UK

You report the view that rewilding and nature restoration in the UK and other European nations risks "offshoring" food and forestry production to places where biodiversity and the environment will suffer. Most rewilding in the UK takes place on land of very poor quality, often where farming has been uneconomic for decades and persists only due to subsidies.

For example, such shifts are taking place on economically ailing dairy land or in the uplands, on former sheep walks and grouse moors that produce little food. Most of the high-quality, pasture-fed beef that is directly produced by many UK rewilding projects is sold in the UK too. In that respect, rewilding produces food rather than offshoring its production.

Time is just a construct, so its advent is fairly recent

22 February, p 31

From Julian Higman, Wantage, Oxfordshire, UK

In a way, the question "When did time begin?" is a non-question. Time is our manufactured, mental measuring stick, expressed as a word, to gauge and so compare motion. In this sense, it will have begun sometime after we started to use speech, between two other questions you posed: "When did *Homo sapiens* originate?" and "When did civilisation arise?"

How to cook a very imperfect boiled egg

15 February, p 19

From John Nicholson, Durham, UK

Talk of how to cook the perfect boiled egg reminds me of trying to cook one in compost. My compost bin was insulated to accelerate decomposition, so got unusually hot. I buried a foil-wrapped egg about 20 centimetres deep in it and left it for 1 hour. The result was a hard-boiled yolk swimming in warm, liquid egg white, a revolting sight that my daughter described as a nightmare egg. I ate it anyway, unharmed, but never tried it again.

Keep the start date of the Anthropocene vague

22 February, p 37

From Pauline Keyne, Beaconsfield, Buckinghamshire, UK

The wish, need or preference to pin down a precise official start date for the Anthropocene is curious. The boundary between the preceding epochs, the Pleistocene and Holocene, says *Encyclopaedia Britannica*, is "around 10,300 ± 200 years" ago. Perhaps it makes sense for the Anthropocene start date to remain uncertain, too.

Dessert brain: What about the cheeseboard?

22 February, p 18

From Nick Hunn, London, UK

Could it be that the research on proclivity for dessert focuses too much on sugar? Most restaurants once offered savoury options for this course. That is now mostly just a cheeseboard. I don't think anyone had issues with having a savoury dessert, which indicates that sugar wasn't a factor.

More good reasons for the rise of square buildings

8 March, p 14

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I have two further possible explanations for the rise of ancient buildings with corners. I would have thought that it would be easier to construct a waterproof roof over a rectilinear structure than over a round one. Also, what about the ease of adding extensions to structures?

Could this be the ultimate nocebo effect?

22 February, p 38

From Philip Davies, Reading, Berkshire, UK

I wonder whether the nocebo effect could affect life expectancy. If, for example, you believe your allotted span to be three score years and 10, will you tend to succumb by age 70? ▮

For the record

▮ **The cosmic dark ages weren't truly dark, as neutral hydrogen atoms absorb light only at some frequencies (22 February, p 32).**

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters
Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

Living on the edge

Some thought string theory was dead because it couldn't describe a universe like ours. But perhaps it can – if we can accept our cosmos is just the boundary of a wilder expanse of reality, says **Jon Cartwright**

STRING theory is the best candidate we have for a theory of everything. Bend to its rule and the various tangled theories of conventional physics emerge as part of a sublime, higher-dimensional tapestry. It can unify all four of nature's forces, including the most troublesome of all, gravity. With any luck, it can also tame big bangs and black holes without losing the thread.

There's just one catch: string theory can't explain a universe like ours. Its maths can describe gazillions of different possible universes, just not one expanding at an accelerating rate, which is precisely what we see ours doing. To be sure, no one knows what is driving this acceleration – a mysterious "dark energy" is the usual placeholder. According to string theory, though, it probably shouldn't be happening at all.

For 25 years, this has been a big problem, but now we may have found a way past it. Superficially, the answer won't shock anyone used to the extravagance of modern physics: we just have to rethink our universe as part of a much grander enterprise. Do this, and it can balloon to its heart's content – indeed, accelerated expansion seems to come naturally. But this new scheme may be the wildest yet, one in which our familiar space is delicately poised between high-dimensional hyperspace and complete nothingness.

"In our proposal, our existence is like a shadow – a projection onto a wall at the end of the world," says Antonio Padilla, a physicist at the University of Nottingham in the UK.

GETTY IMAGES/SHUTTERSTOCK

For all its present-day grandeur, string theory has humble roots. It grew up in the late 1960s as a simple equation to make sense of collisions between protons, neutrons and other particles glued together by what is called the strong force. Back then, it wasn't called string theory, but the name soon took after physicists realised that its collision probabilities could be interpreted as the different vibrations of quantum-mechanical strings. Tentatively, they began to wonder if the strings were more than mere tools to help understand particles – maybe they actually were the particles. In this picture, each fundamental particle – be it an electron, a quark, a Higgs boson or whatever – is actually the end of an infinitesimally tiny string, humming a particular tone.

As it happens, string theory initially stumbled in its efforts to properly calculate the strong force, though it quickly made headway elsewhere. There are three other known forces of nature: the weak force, which governs radioactivity; electromagnetism, which concerns light and the chemistry of everyday matter; and gravity, which is something of an oddball, making everything attract. String theory's first major success was to achieve what previous quantum theories had never managed, and describe gravity. Later, the weak force, electromagnetism and the strong force, too, came under string theory's umbrella. Suddenly, it was the front-runner as a viable theory of everything.

Its maths was bold, requiring 10 dimensions of space-time. We are familiar with just four dimensions – that is, three of space and one of time – but string theorists believe there are six more and that they are so minuscule as to be invisible to our senses or any current instruments. While the extra dimensions made the equations work and freed up space for the strings to curl up in, they also unleashed a host of other weird, higher-dimensional objects, somewhat misleadingly called membranes, or branes for short. Still, this was the 1980s. Anything was possible.

A stringy disaster

Unfortunately, it turned out that string theory was so flexible it could describe a truly vast array of fantastical universes. Something like 10^{500}, in fact – a number so huge it belied any physical comparison and made a mockery of predictive science. Worse, astronomical observations in the late 1990s of distant supernovae revealed an amazing truth: that our universe is expanding faster and faster. Perplexing though this was for physicists in general, it was a disaster for string theorists. Very few of the universes in their immense selection had this accelerating property. "People began to wonder if our sort of universe is really just impossible in string theory," says Ulf Danielsson, a theorist at Uppsala University in Sweden. "Today, we still simply don't know."

It might seem odd that string theory struggles with something so apparently mundane as an accelerating universe. The reason is that the rate of expansion comes from the very geometry of space-time, as ›

New Scientist audio
You can listen to many articles – look for the headphones icon in our app **newscientist.com/app**

"What we see and feel would be just a projection of a greater reality, beyond our senses"

defined by Albert Einstein's general theory of relativity and later descibed in detail by cosmologist Willem de Sitter. In one solution to Einstein's equations, space-time is spherical and expanding at an accelerating rate – what's now known as a de Sitter (dS) space. In the alternative solution, space-time is saddle-shaped and cannot expand at all, called an anti-de Sitter (AdS) space. String theory strongly implies that only AdS space-times are stable and able to support themselves, even though a wealth of astronomical data, including from those distant supernovae, confirms that our present-day universe is dS.

The seed of an idea to get around this impasse was planted even before physicists had fully got to grips with dark energy and the accelerating universe. In 1999, in an attempt to solve an entirely different problem in string theory, theorists Lisa Randall and Raman Sundrum toyed with the concept of high-dimensional branes, albeit in a less extravagant, easier-to-describe, five-dimensional (5D) setting.

In geometry, the surface of an object always requires one dimension fewer than the object itself – for instance, each face of a 3D cube is a 2D square. Likewise, Randall and Sundrum discovered that it was possible to have a pair of 5D AdS space-times separated by a brane that was merely 4D, just like our universe. Moreover, Randall's later work with theorist Andreas Karch showed that this brane would have an accelerating, dS geometry – again, just like our universe. Did we live on a brane? The possibility was tantalising.

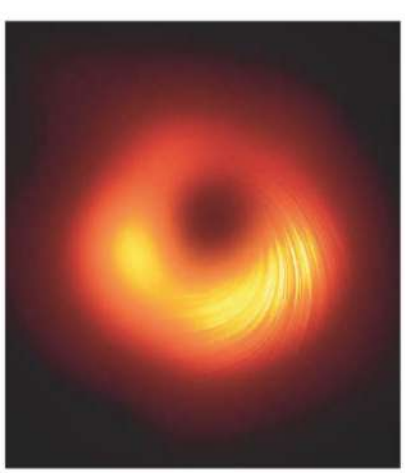
Alas, despite its superficial promise, the Randall-Karch brane never much helped to ease string theory's woes. The reason was that, sandwiched between two mammoth AdS space-times, it wasn't much more stable than the few pure dS universes that could be wrenched out of string theory. About five years ago, however, Danielsson and his colleagues at Uppsala University had an epiphany. "We thought, what if instability wasn't a problem?" he says. "What if we could turn it to our advantage?"

Every space-time model has a certain level of energy woven into its fabric, governing the types and behaviours of the particles, strings, branes and other entities that may be contained within it. If a space-time doesn't reside at the lowest possible energy, quantum mechanics says it is inherently unstable and has the risk of "decaying", suddenly transforming into a new universe in which the energy is lower. Danielsson's group considered a 5D AdS space-time that begins high on this energy ladder, and found that if even a tiny part of it decays, this fragment quickly forms a "dark bubble" of lower-energy 5D AdS space-time. As in the Randall-Karch scenario, this bubble is enclosed by a 4D dS space-time like our own – yet crucially, it arises out of instability, rather than being at the mercy of it.

In this new scenario, the bubble membrane on which our cosmos is poised still wouldn't be perfectly stable. But that just means another dark bubble would occasionally pop up, or nucleate, within its inner 5D space-time, which we can't see. In fact, new dark bubbles would continually nucleate within each other, each enclosed by a dS brane – in effect, a new universe. In this grand multiverse, what we refer to as "the" big bang would be just the moment our parent bubble gave birth to ours.

Danielsson argues that this idea is actually more intuitive than accepted big-bang cosmology. "A favourite picture of the big bang is that it's like a balloon expanding into space," he says. "Usually someone tells you that's wrong: the balloon isn't expanding into space, because that extra space – the beyond – simply doesn't exist. But with the dark bubble, actually it does."

Images of black holes like this one may hint at the existence of extra dimensions



EHT COLLABORATION

Leaking gravity

However, there is a fear that, on closer inspection, the bubble may burst. The issue has to do with that most pesky of nature's forces, gravity, and, in particular, why it is so weak. A common illustration of gravity's weakness is the comparative strength of a fridge magnet, which is able to exert enough electromagnetic force to stick to a metal door and, in so doing, counteract the gravitational pull of the entire planet. String theory offers a generic, hand-waving answer to gravity's feebleness: with 10 dimensions to act in, gravity is somehow diluted more than the others. But if gravity is leaking away, theorists still have to explain why it isn't so weak as to let planets escape their orbits and spinning galaxies fly apart.

The trick is to somehow confine gravity so that only a little – just the right amount – seeps away into the extra dimensions. Padilla argues that dark bubbles don't successfully do this. After all, the dark bubble multiverse is infinite, so gravity can potentially leak anywhere. As a result, Danielsson's group has had to introduce additional strings in their fifth dimension to tether gravity to the bubble membranes.

"To us, it looked like you have to jump through hoops to get gravity to look 4D," says Padilla. For this reason, he and his colleagues Ben Muntz and Paul Saffin at the University of Nottingham began to toy with an alternative solution: get rid of the multiverse and have just one bubble. With no infinite space-time, gravity's leakage is stemmed, allowing it to be weak, but not too weak. And while our world is still the 4D brane surrounding a 5D bubble, it is now also the barrier between a 5D cosmos and pure nothingness. In other words, it is literally the edge of the universe, an "end of the world" brane. "Of course, this also presents a problem," says Padilla. "What's nothing, and how can something come out of it?"

How to get something from nothing is a vexed question, to say the least. From the dawn of philosophical thought, people have

CERRO_PHOTOGRAPHY/GETTY IMAGES

Our universe may just be the membrane on the edge of a higher-dimensional bubble

wondered how space, time, substance – even the rules governing those things – can arise if there is nothing there to begin with. As physics deals with relationships between entities, there seems little hope that it can ever fully answer this mystery.

And yet, as theorists Adam Brown and Alex Dahlen showed in 2012, when they were both at Princeton University, it can get surprisingly close. Drawing on earlier work by their then Princeton colleague and string theory heavyweight Ed Witten, they posited the case of an AdS space-time geometry that curves infinitely in on itself. Such a geometry is like a piece of paper that has been crunched up more and more, each scrunch adding curvature, until it is infinitesimally small. This, said Brown and Dahlen, is pretty much the best "nothing" you can define within the framework of physics.

A space-time with this geometry is an inhospitable place indeed. At infinite curvature, all lengths shrink to zero, so there simply wouldn't be any space for anything to exist. On the other hand, quantum mechanics would still reign supreme, and quantum mechanics doesn't allow any such definitive statements. Where there is nothing, it says, there is still the fleeting chance of a little something – the teeniest of spaces for a bubble space-time to nucleate.

The Nottingham group wanted to exploit this possibility but faced another problem. If the parent space-time is infinitely curved, how can a bubble formed within it have a benign geometry? Fortunately, physicists are used to grappling with this kind of issue. In quantum field theory, which underlies our current standard model of fundamental particles, physicists routinely have to cancel out high-energy terms in their equations, lest their answers turn infinite. Although it can sound arbitrary, this "renormalisation" process works: witness the amazing precision with which physicists predict the rates of collisions at particle smashers such as the Large Hadron Collider.

Last year, Padilla and his colleagues employed a similar procedure, known as holographic renormalisation, when calculating the nucleation of a finitely curved bubble within an infinitely curved AdS space-time. It was a success. "The result is exactly described by an end-of-the-world brane, with nothing outside," says Padilla.

Inside the bubble

Superficially, it seems that the universe we think we know could really be this brane, with nothingness on the outside and a 5D bubble on the inside. If that is the case, Padilla points out that the strings making up our everyday existence would really be living in the 5D space inside the bubble, with only their ends, which we perceive as the fundamental particles, stuck to our 4D braneworld. In that case, these particles – what we see and feel – would really be a shadow or projection of a much greater reality beyond our senses.

Still, it should be noted that neither the Nottingham nor the Uppsala group's ideas are fully fledged string theories. Because the researchers' proposals have only five dimensions, they need to demonstrate that the rest of string theory's 10 dimensions can successfully be compacted into their worlds. "The full string theory embedding of this scenario will likely come with new obstacles," says Ralph Blumenhagen, a string theorist at the Max Planck Institute for Physics in Garching, Germany.

Although the Uppsala group has claimed some progress towards this goal, significant challenges remain as those obstacles begin to reveal themselves – and a path through isn't clear. "This may be just a technical difficulty or it may be a reflection of a more fundamental obstruction," says Angel Uranga at the Institute of Theoretical Physics in Madrid, Spain.

But even if they are successful theoretically, it is tempting to ask: are the ideas simply a little too out-there? Physicists can test for gravity leaking into extra dimensions by looking for deviations in the laws of gravity as we know them, either in the behaviour of balances and cantilevers in tabletop experiments or, as has only recently become possible, in the sizes of black holes in astronomical imagery. They can also use particle colliders to search for the energy signatures of gravitons, the particles thought to carry the force of gravity, operating in higher dimensions. Unfortunately, the precision of these tests isn't yet sufficient to rule out or provide evidence for the braneworld scenarios, although it is improving all the time.

Meanwhile, the ideas have injected new optimism into string theory – a glimmer of hope that, despite all its difficulties and excesses, it might be able to describe our humble expanding universe after all. "It's definitely too early for a final verdict," says Blumenhagen. But the possibility that we live on a brane may mean that the acceleration of our cosmos isn't truly the end of the world for string theory. ▮

Jon Cartwright is a science writer based in Bristol, UK

"Animals have evolved all these fascinating ways to deal with infections"

The realisation that wild animals possess medical know-how isn't just intriguing; it could also benefit us, our pets and our livestock, as biologist **Jaap de Roode** tells Graham Lawton

TWO decades ago, Jaap de Roode made a discovery that changed his scientific career. While researching the ecology and evolution of parasites and their hosts, he came across something truly surprising: the monarch butterflies he was studying seemed to be exploiting the medicinal properties of plants to treat themselves and their offspring.

Back then, the notion that an insect might be capable of self-medicating seemed far-fetched. Now, de Roode is a world expert in the burgeoning field of animal medication, with a lab of his own at Emory University in Atlanta, Georgia. He spoke to *New Scientist* about his work, his new book, *Doctors by Nature: How ants, apes and other animals heal themselves*, and his belief that animals possess medicinal knowledge that we can use to improve our own health.

Graham Lawton: How did this unlikely area of research get going?
Jaap de Roode: It started during work in Tanzania in the 1980s with a chance observation. Michael Huffman of Kyoto University was working with Mohamedi Seifu Kalunde, a national parks ranger, to look at the role of elderly chimpanzees in society. While tracking one called Chausiku, they noticed that she was withdrawn, she was taking naps during the day and she had diarrhoea. They saw her go to a plant called *Vernonia*, also known as bitter leaf. She stripped off the bark and started sucking the pith. This is not normally part of their diet. Seifu, who was also a traditional healer, told Huffman that he uses it as a medicinal plant. The next day, they saw Chausiku had recovered. That was the moment Huffman thought, well, maybe she is using medication.

Was she?
A lot of studies followed to figure that out. They looked at every step. Was a chimp sick? Does the plant have medicinal properties? If chimpanzees are sick and use this plant, does it help them? They found there are chemicals in this plant that kill intestinal worms. So, yeah, it's a medicinal plant, and chimpanzees use it when they are sick.

That was the first proven example. Any others?
People including Jane Goodall had already observed that chimpanzees often swallow leaves. They fold them over and swallow them – they don't chew or digest them – and they poop them out whole. The idea was that those leaves also have chemicals that are bad for worms. But it turned out that they are really rough, like Velcro. Worms get stuck on them. The leaves also irritate the gut, so it purges the gut. It is medicine.

How did you make your own discovery?
I was studying monarch butterflies, trying to understand parasite evolution. There is a parasite quite similar to malaria, *Ophryocystis elektroscirrha*, that infects monarchs. One ›

BECKI GILL

"I thought: 'wow', maybe these butterflies can use this as medication'"

Monarch butterflies use milkweed as a medicine

JAAP DE ROODE

feature of monarch caterpillars is that they eat only milkweeds, which contain chemicals called cardenolides. They use these plant toxins to make themselves poisonous to predators. I knew about the chimpanzee studies, so I thought, let's see if milkweeds also have an effect on the parasite. I reared monarchs on different species of milkweeds and found that when the plants were more toxic, the monarchs became less infected and suffered lower parasite burdens and less disease. My thought was: "Wow, maybe these butterflies can actually use this as medication."

How did that idea go down?

I think it was easier to accept that chimpanzees can medicate, because we give them credit for intelligence that we don't give to other animals. When we wrote the first paper that showed the milkweeds had a medicinal effect [in 2007], a peer reviewer said there was no way monarchs can do this. So we had to remove it. But that didn't stop us. We did experiments. We had infected and uninfected caterpillars, and we gave them a choice between medicinal and non-medicinal milkweed. They had no preference. Then we looked at female butterflies. One of the ways the parasite spreads is from mothers to offspring: when the female is infected, she is covered in parasite spores and these get scattered onto the milkweed and the caterpillars eat them. What we found is that infected female butterflies have a strong preference to lay their eggs on the medicinal milkweed. And that helps their offspring. It was a very clear medicinal effect.

Did those results convince the sceptics?

From the late 2000s, a lot of papers started appearing. When woolly bear caterpillars are infected with parasitoid flies, they increase their consumption of alkaloids, a type of chemical that kills these flies. Wood ants incorporate tree resin into their nests and it helps against the growth of microorganisms. For the woolly bear caterpillars, it is self-medication. For the wood ants, it is prophylaxis. So, it was becoming a trend at the time, which helped in the acceptance of our findings.

Many more examples have since been discovered. Which are your favourites?

When sheep are infected with worms, they prefer to eat plants that have more tannins in them: sheep normally hate tannins, but tannins kill worms. Once the symptoms go away, they stop.

There is also fumigation. A lot of animals do this, but I love the birds and the butts story. Researchers at the National Autonomous University of Mexico in Mexico City discovered this when they were studying how urbanisation is affecting nest building in house finches. They saw all this white fluff in the nests and they didn't know what it was. But then, when a nest was wet, one of them realised, "Oh, it smells of smoke. These are cigarette butts." They also found that when there were more cigarette butts in the nest, there were fewer lice, mites and ticks.

To demonstrate that these birds do this on purpose, they took nests, removed the lining and put in an artificial one. Then they added live ticks, dead ticks or no ticks. What they found is that the birds that had live ticks in their nest started collecting more cigarette butts. It's not an accidental thing. They are purposefully changing their behaviour in response to a threat. In natural conditions, finches collect all sorts of aromatic plants and put them in their nests. They especially use nicotiana plants, which have the same chemicals as the butts. I think they can smell the chemicals.

What other methods do animals use to stay healthy?

One of the most intriguing examples is anointing. Cats love catnip. When they are exposed to it, they start rolling around in it. They go into this frenzy and you can tell they're having a good time. But the question has always been, why do they like it? Research in Japan found that when cats roll on catnip, they coat themselves in a chemical that repels mosquitoes.

How do animals know when and how to medicate?

To some extent, they don't need to. Cats don't have to know that they are coating themselves in chemicals. All they need to know is that what they are doing gives them a lot of pleasure.

The question is, how does it evolve? For a lot of systems, we don't know. But with the woolly bear caterpillars, the researchers really dissected what is going on. The caterpillars have four different taste receptors and one of them tastes the alkaloids that kill the parasitoids. When they have an infection, that

SHUTTERSTOCK/KAREL BOCK

taste receptor starts firing more rapidly, so they get more nerve impulses going to the brain. Alkaloids suddenly taste really great and they want more of them.

So, there are some innate mechanisms where physiology tells the animal how to respond. There is also individual learning. A lot of animals taste different things by trial and error, and they can make associations. For example, there is work showing that goats pair their experience of symptom relief with the intake of particular plants or chemicals. And then there is social learning. Chimpanzees learn from each other how to swallow leaves. They can fold them in many different ways before they swallow them and different groups of chimpanzees have adopted different techniques.

There was a paper last year documenting a wild orangutan treating a facial injury with medicinal leaves. Why don't you give any examples of wound healing in your book?
I felt I had to focus on where the evidence is clear. With that orangutan, I would like to see more observations. I would like to see that it actually helps, ideally in experiments, but you cannot do that with orangutans.

How can people who live with animals allow them to take advantage of their ability to medicate?
We have dictated everything for our pets without letting them be their own doctors. I spend a lot of time in parks and people's response to seeing their dogs' natural behaviours is always interesting: "Don't eat the dirt!"; "Don't eat the grass!" When my dogs decide to eat grass, I let them, because their body is telling them to do it. Sometimes they poop it out. Sometimes they throw up. With cats, if you have a yard, or even a balcony, make sure to plant some catnip.

And what about farm animals?
Right now, we don't give them opportunities for natural medication, so we have to give them tons of antibiotics and anthelmintics that kill worms. By allowing them to eat more varied diets that they can use for medication, we don't need those. It makes our animals healthier. It also prevents drug resistance from evolving, which is a direct medical benefit to us.

The examples in your book were all discovered by accident, so surely there must be many other instances of animal doctors out there?
I think we are going to find others. For now, it is really only vertebrates and insects. We have ignored worms, sponges, snails, all sorts of things. And octopi: they are really smart. One thing I hope to achieve with this book is to say: "Hey, now that we know that animals do it, let's do a study to find out what animals use medication – and what we can learn from it."

What can we learn?
People have looked at animals for inspiration for a long time. Healers in Seifu's community learned from porcupines how to treat diarrhoea. They learned from the elephants that make treatments for upset stomachs. Many Native Americans have medicines that are based on looking at what bears do. Oshá root, which treats infections, is a good example.

Animals have evolved all these fascinating ways to deal with their infections and their health using all sorts of medicines that they find in nature. We can see what they use their medicines for and we can use that as a way of narrowing down what things we should look at to make our own medicines. There is just so much knowledge out there in the animal kingdom. ▮

House finches (above) are known to fumigate their nests with cigarette butts. The self-medicating behaviour of woolly bear caterpillars and chimps (below) have also been studied

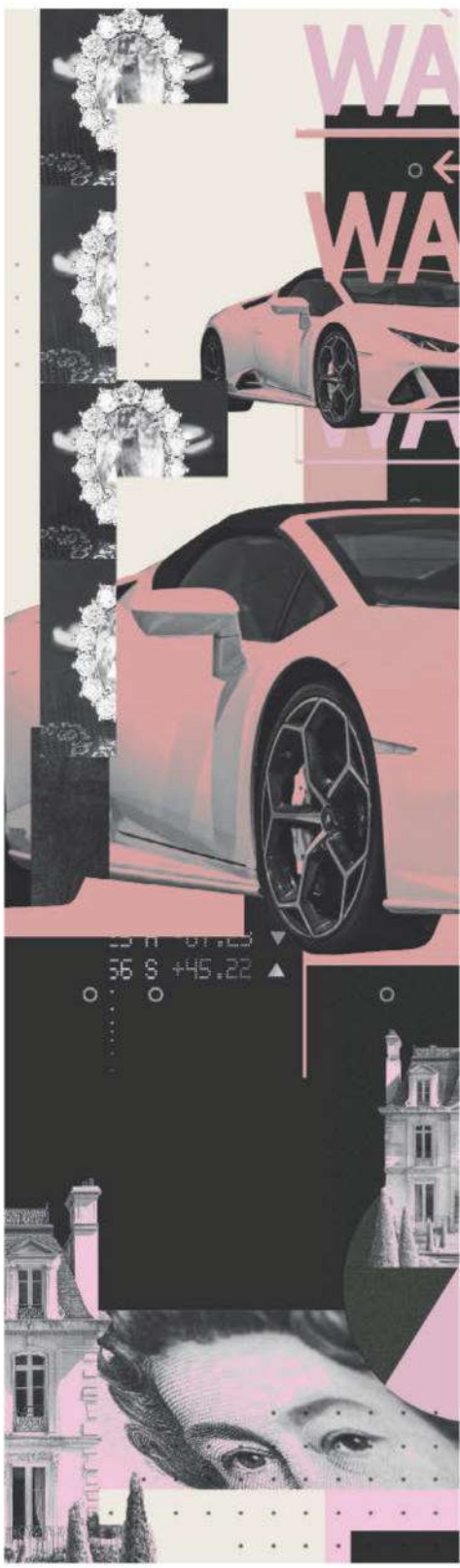
MICHAEL SINGER

MICHAEL A HUFFMAN

Graham Lawton is a features writer at *New Scientist*

The money question

Some people worship money, to others it is the root of all evil. Why do attitudes differ so wildly and what is a healthy view, wonders **Emma Young**



CONVERSATIONS with your hairdresser can be quite revealing. And when I went for a trim earlier this year, the gossip was especially good. It was close enough to Christmas for our chat to turn to gifts and giving and, as he snipped away, my stylist had some juicy anecdotes to share. One customer had complained that despite her sister being about to buy a £1 million house, she still moaned about contributing £20 towards a gift for their aunt. Another described presents from her son as "a bit thin". And a third felt physically sick at the amount his family members had spent on his young nieces.

Money, money, money. We have such different attitudes towards cash, but taboos make it tricky to talk about. As a result, it can drive a wedge into otherwise happy relationships. This is exacerbated by growing financial divides: analysis from a charity called the Fairness Foundation found that, between 2011 and 2019, the wealth gap between the poorest and richest UK households grew by 50 per cent – and the situation is even worse in the US. Yet psychologists have only recently begun truly getting to grips with why money is such a deeply emotional topic for us – something filled with meanings and belief – rather than simply a necessity to pay the bills.

Now, they are unpacking everything from how and when our ideas about money develop to what constitutes a healthy – or unhealthy – relationship with the stuff. Psychologists may be late to the party, but some of their findings are surprising. Others are counterintuitive. Above all, they are putting a new spin on why money is so divisive.

One obvious fact about money is that, at a basic level, of course it matters: it buys us the essentials of survival. More controversially, it can also buy happiness. In 2010, research by Nobel laureate Daniel Kahneman and his colleagues suggested there is a "well-being plateau" that kicks in at an annual income of $75,000 (around $108,500 in today's money), above which earning more won't make you feel any better. Since then, a survey of more than 33,000 people in the US with incomes ranging from $15,000 to $480,000 per year, found that as earnings increased, even beyond $75,000, so did well-being. And a 2023 study by researchers from both groups confirmed this to be true – for most people at least.

Proof, if it were needed, of the deep psychological impact of money is even visible in brain images. Making a loss or being hit by an unexpected bill activates similar regions to those that fire when you experience pain, particularly social pain, such as being ostracised by friends. Brain imaging also shows that we feel monetary losses more strongly than equivalent gains – reflecting a well-known psychological bias called loss aversion. And when money is very tight – as it is for many people right now – neurons fire in the brain's amygdala and hippocampus, initiating the physiological stress response. This can affect both mental and physical health, says psychologist Giulia Sesini at the Catholic University of the Sacred Heart in Milan, Italy. Constant financial worries can lead to a cognitive overload. "When this happens, our cognitive resources are so busy focusing on potential threats and issues that it might impair our ability to make good financial and life decisions," she says.

SKIZZOMAT

Nevertheless, whatever their wealth, the way any two people think about money is likely to differ. What's more, a widespread reluctance to talk about it means we seldom get an insight into how much our views vary or why. A UK study, for example, found that two-thirds of young people see money as a taboo topic. Psychologists are now bridging that gap.

Our response to money – or at least its equivalent in terms of material resources – starts earlier than you might imagine. New research indicates that infants have already begun to judge people by markers of wealth at 15 months – and they prefer interacting with those who appear richer. That may sound mercenary, but in evolutionary terms, displays of wealth are "honest indicators of fitness", and it makes sense for infants to affiliate with fit individuals because

"Making a loss activates similar brain regions to when you experience pain"

that increases their chances of survival.

Given that an understanding of who has assets and what that means takes hold early, it isn't surprising that the income, social class and financial habits of parents have a big impact on children. "The familial context plays a pivotal role in shaping attitudes towards money," says Sesini. That isn't to say the lessons of your early years set such attitudes in stone. As we grow older, she says, life-changing events, such as parenthood and bankruptcy, can drive big shifts in our views and financial behaviour. What's more, even within the same family, differences in children's exposure to their parent's fiscal stresses – or profligacy – combined with personality differences and individual experiences, can make for strikingly divergent attitudes in adulthood.

To drill down into these outlooks, psychologists use a variety of questionnaires that capture perceptions, beliefs and feelings related to money. These tend to comprise sliding scales that measure things like the degree to which you favour saving for the future versus spending now, how anxious you feel about money, how hesitant you are in situations that involve it, and the extent to which you see finances as a means to show off and influence others. Some studies focus specifically on ›

BOB HENRY/ALAMY

the concept of "love of money". Here, the scale records things like how keen you are to be rich, how motivated you are by a desire for money, and how important, good and valuable you think it is.

Sesini recently led two major reviews of such research. In the first, she and a colleague analysed results from 226 papers exploring a range of potentially influential factors, such as age, personality, personal values and wealth. A few patterns were quite clear. For one, younger people tend to attribute greater importance to money and associate it more strongly with power and freedom. They are also more anxious about it – perhaps unsurprisingly, given rising student debts, unaffordable housing and stagnating salaries in many places.

Some personality traits are influential, too. Neuroticism and conscientiousness, for example, can increase financial anxiety. Conscientious types are often less materialistic. And introverts are more likely than extroverts to view money as evil. There is also a link between "love of money" and unethical behaviours, such as lying and cheating. Other factors were less clear cut. Several studies (mostly in the US) indicated that wealthier people were more likely to believe money can solve all problems. However, a study in the UK concluded that such attitudes are more common among people on lower incomes.

In a second review, Sesini and her colleagues looked at differences between men and women. Here, most of the 100 relevant studies had been conducted in the US, with a few in Europe and Asia. Together, they paint a puzzling picture. The men surveyed tended to see money as a way to control, influence and impress other people, and as a symbol of power and prestige – this was true for those in both higher-income and lower-income countries. Overall, they had higher "love of money" scores than women and were more likely to believe that becoming richer would make them more attractive and desirable.

The women's attitudes were more complex. They were more likely to view money as a source of anxiety and stress – but also to associate it with security and love. The studies span a period from 1972 to 2021, but even the newer ones found these disparities, despite women having better work opportunities and greater financial independence in recent decades. "It may take time to fully appreciate the tangible effects of these changes," says Sesini.

Culture, too, strongly influences attitudes to cash. Research into the psychological effects of money tends to be concentrated on people living in WEIRD – Western, Educated, Industrialised, Rich and Democratic – countries. Last year, however, Danila Medvedev at the University of Chicago and his colleagues published work highlighting the differences between WEIRD and non-WEIRD countries, specifically the US and UK versus China, India, Mexico and South Africa. The results were unexpected. "The basic intuition we have from an economic perspective is that someone from a less-wealthy country should be more motivated by a single dollar than someone from a wealthier country," says Medvedev. "We show the opposite. And the effect gets stronger as we move to countries that are more dissimilar to the US."

For WEIRD participants, work ethic was more tightly tied to monetary incentive. One particularly notable finding was that as soon as US participants had done enough to qualify for their base pay, over half of them quit the task, while more than 90 per cent of Mexicans continued with it. But Medvedev cautions that this could simply reflect a less contractual approach to work in non-WEIRD countries.

"Research reveals why ostentatious displays of wealth often backfire"

Although there is still more to learn about the factors that shape our individual attitudes to money, psychologists are also keen to work out how these views influence our behaviour and well-being. One key finding is that "love of money" attitudes are a problem. While having enough to comfortably provide for yourself and the people you love inoculates you from the downstream health impacts of financial stress, Gabrielle Pfund at Washington University in St Louis, Missouri, and her colleagues have found that your concept of wealth matters. The more value someone places on wealth, they found, the less likely people are to report feeling a sense of purpose, personal growth, self-acceptance, environmental mastery and life satisfaction, and the more negative emotions they tend to experience. Sesini's work provides a clue as to why. It shows that people who view money as a sign of power, status and prestige tend to be more impulsive, less friendly and more Machiavellian – cunning, scheming and unscrupulous.

Research also reveals why ostentatious displays of wealth often backfire. Although studies indicate that people tend to think flashing the cash will help them win friends, a team led by Shalena Srna at the University of Michigan found the opposite. Participants

Your culture is just one factor that can influence how you view money (left)

CHRISTOPHER FURLONG/GETTY IMAGES

The stress caused by poverty can damage people's physical and mental health

in an online game of cooperation were less likely to choose partners who had dressed their avatar in a shirt featuring a designer logo, rather than an unbranded shirt – even if they had chosen branded clothing for their own avatar. "Wealth signalling reveals two things: that a person is wealthy and that they have decided to show off their wealth. It is the showing off that's bad for your image as a cooperative person," says Deborah Small at Yale University, who was part of the team.

It is now well-established that being materialistic – having an excessive focus on acquiring wealth and possessions that display status – also undermines relationships. Research published last year might help explain this. When Olaya Moldes at Cardiff University in the UK exposed people to money-focused, status-related messages, such as ads for luxury brands, they had higher expectations of others – in particular, wanting them to be more attractive and more ambitious – which would seed dissatisfaction with the people around them. But being non-materialistic isn't necessarily a better way to go. In their study on the influence of various factors on financial attitudes, Sesini and her colleague found that less materialistic people tend to have a "conservative, retentive" approach to money – some might call them "careful", others would say "tight". Either way, as well as being less likely to get into debt or end up bankrupt, they are also more likely to feel anxious about money, and more inclined to save in an "excessive and irrational way".

Given such findings – and the apparent tightrope between having enough money and maintaining some sort of psychological distance from it – the million-dollar question is "What is a good attitude to the stuff?" Of course, there is no one right answer. Being aware of how money manipulates your behaviour and mind should help. The scientific literature also offers some pointers about how to get the most bang for your buck in wellness terms. If you have cash to spare, giving some to others will boost your happiness. So too will buying experiences rather than things, but only if you can afford to do so. And using money to free up your time – like choosing the more expensive gym that is closer to your home, paying for supermarket deliveries or taking your family for a meal out on a Friday night, rather than spending hours chopping vegetables and washing dishes – will leave you feeling more satisfied and less stressed. "Before buying that new pair of shoes or the latest gadget," says Medvedev, "ask yourself: 'Is this worth more to me than extra time or meaningful moments with loved ones?'"

Such advice will ring hollow if you are struggling to get by. Knowing that your brain is registering social pain and stress won't help much either. Worse yet, psychologists have found that poverty impacts our cognitive function, undermining the ability to make good financial decisions. Nevertheless, research by Qiyan Ong at the National University of Singapore and her colleagues offers a ray of hope. They found that giving people a one-off debt-relief payment both reduced stress and improved cognitive function, helping them escape the poverty trap.

Sesini, for her part, believes we can also all benefit from deeper personal exploration. "Ask yourself: 'How do I feel when I think about money?' " she says. "This simple question can reveal a great deal about your relationship with money and offer valuable insights into your personal attitudes and emotions." Talking about these insights could benefit romantic relationships and improve broader family dynamics, she adds. And while being more open about money might not prevent grumbles about tightness or profligacy, it might just help us break down some taboos. That can only be a good thing because, as my gossipy hairdresser highlighted, a reluctance to broach the subject of money is keeping many of us from sharing our honest perspectives with those we love. ▮

THOMAS TRUTSCHEL/PHOTOTHEK VIA GETTY IMAGES

Some think that signals of wealth and luxury will help them win friends

Emma Young is a writer based in Sheffield, UK

Boost your investments with 1% cashback.

Move your ISAs and pensions over to us and get 1% back in cash on transfers of up to £500,000, to invest or withdraw.

Nutmeg.
a J.P.Morgan company

Get the offer

Capital at risk. £10k min transfer. Initiate by 30.05.25 and keep invested until 30.05.26. Product rules and T&Cs apply. Compare existing benefits and fees before transferring.

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
Could alien life live for many hundreds of years? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
A new Lego set takes a bit of a wrong turn p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

Debunking gardening myths

Potting up

Traditional advice tells us to only move growing plants to a pot one size larger. Don't bother with this slow transition, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

OLD-SCHOOL gardeners are notoriously suspicious of trendy new ideas in horticulture, and with good reason. Planty social media is often filled with claims so colourfully fact-free they would make the average well-being influencer blush. But before older growers like me get too smug, it is worth remembering that much of the best-established gardening advice, when actually put to the test, also turns out to be based on pretty shaky evidence. It is hard to find a better example of this than the widely held fear of "over-potting". Let me explain.

When potted plants outgrow their containers, the seemingly unanimous advice from the gardening establishment is that they can only be moved to a pot one size larger. In practice, this means giving the plants only a few extra centimetres around their root ball. Break this rule, and even august institutions like the Royal Horticultural Society claim that plant roots will start to rot – due to the excess moisture trapped by the large volume of potting soil – after which they will start to lose their leaves and then collapse.

The basic idea seems to be that bigger pots have a smaller surface-area-to-volume ratio, meaning they lose moisture much more slowly. Without a great mass of thirsty roots to wick it away, this excess moisture leads to decay. The problem is, when you actually look for evidence to support this idea in the scientific literature, it just doesn't seem to be there.

You might think this is due to a lack of trial data, which shouldn't negate centuries of accumulated knowledge. But the effect of pot size on plant growth has been tested more than once or twice before – unsurprisingly, given that the horticulture industry is worth billions – and the findings of these studies are the opposite of what the theory of over-potting claims. In fact, a meta-analysis of 65 trials in a range of plant species found that "on average, a doubling of the pot size increased biomass production by 43%".

So, according to a pretty hefty stack of studies, moving straight to a much larger pot size, rather than slowly transitioning up a series of containers, is better for plant growth. It also means putting in significantly less effort, and it is cheaper and potentially more sustainable, too, as you don't have to buy all the in-between pot sizes. For plants that are sensitive to root disturbance, whose growth can suffer after repotting (and there are loads of those), skipping these interim steps is likely to be particularly beneficial.

Even if we give tradition the benefit of the doubt and imagine that over-potting has the claimed effect – of an over-accumulation of moisture – there is a simple way to get around the problem: just water less. In other words, reduce your workload even further, while delivering better results for your prized plants, like this tomato plant, pictured. I'm in. ▮

GAP PHOTOS/GARY SMITH

These articles are posted each week at newscientist.com/maker

Debunking gardening myths appears monthly

Next week
The science of exercise

TUESDAY 20 MAY 2025

155 BISHOPSGATE, LONDON

NewScientist

EMERGING TECHNOLOGIES SUMMIT

Empowering leaders to leverage emerging technologies for growth and resilience

Advance saver rate ends on 21 March

Join us for the second New Scientist Emerging Technologies Summit, where we bring together scientists and business leaders to explore the exciting challenges and opportunities of cutting-edge technologies. Gain insights from visionary keynote speakers and industry experts as they share their knowledge on the latest technological advancements that will shape the future of business.

- Explore real-world case studies of quantum computing that show its tangible impact on businesses today, proving it's more than just theory.
- Learn how cutting-edge robotics and AI can boost efficiency and transform operations.
- Master AI's potential to make smarter decisions and unlock its full value for your business.
- Unlock satellite-driven insights from space data to boost growth, cut costs and improve decisions.

ASSOCIATE SPONSORS

Access Partnership

ocado TECHNOLOGY

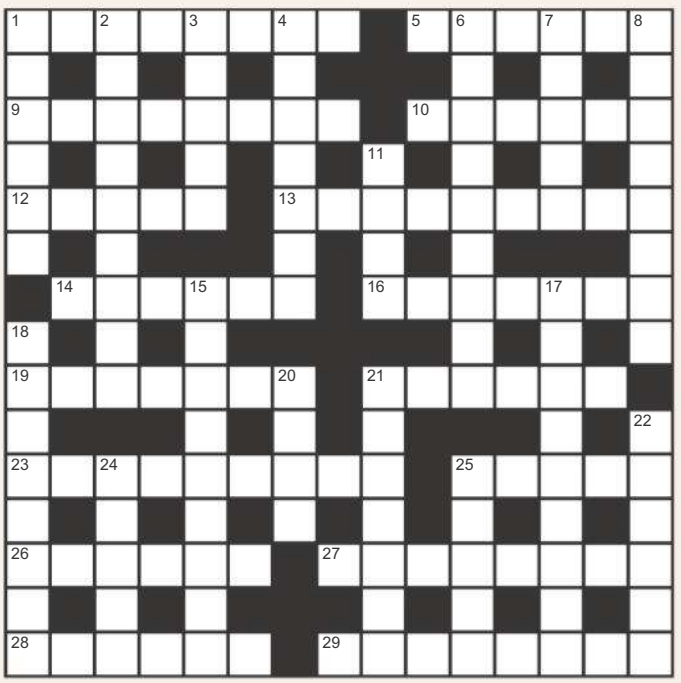
SKYRORA

SUPPORTER

techUK FOR WHAT COMES NEXT

Find out more at newscientist.com/summit2025

Quick crossword #179 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Old term for an absence seizure (5,3)
5 Airborne (6)
9 Spinal curvature (8)
10 Taxonomic rank above 12 Across (6)
12 Taxonomic rank below 10 Across (5)
13 Waste-water process (4,5)
14 Category within a category (6)
16 Waste away (7)
19 OpenAI application (7)
21 Nucleotide variation (6)
23 Introductory article or outline (9)
25 Canines, incisors, etc. (5)
26 Pulsates (6)
27 Carcinogenic silicate mineral (8)
28 ___ acid, substance such as H_2SO_5 or H_3PO_5 (6)
29 Female sex organ (8)

DOWN

1 Thick airway mucus (6)
2 Venomous spider (9)
3 Utensils; hardware (5)
4 Precise portion (of a sample) (7)
6 Foliate polyp structure (4,5)
7 Relating to the small intestine (5)
8 ___ trinitrate, angina medication (8)
11 ζ
15 Railway control hub (6,3)
17 Synthetic fabric (9)
18 Threaded cap (8)
20 Vat; armoured vehicle (4)
21 Small particles suspended in gas (7)
22 Rh (6)
24 Less polluted (5)
25 Microblog (until recently) (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #294
set by Corryn Wetzel

1 Which planet in the solar system takes the longest to completely rotate on its axis?

2 Corals and sea anemones belong to which phylum?

3 What is the primary metal found in chlorophyll?

4 What is the name of the largest shield volcano on Earth?

5 Which vitamin is essential for blood clotting?

Answers on page 47

BrainTwister
set by Peter Rowlett
#65 Prime magic squares

A magic square is an arrangement of numbers where all rows, columns and diagonals add up to the same number, called the magic constant. Can you complete this square by filling in the missing numbers?

43	1	
61		13
	73	

This square was discovered in the early 20th century by Henry Dudeney as a magic square of prime numbers. Unfortunately, it contains 1. Modern mathematicians define prime numbers so that 1 isn't prime, because it makes lots of results less awkward to state.

An alternative magic square of prime numbers uses 5, 17, 29, 47, 59, 71, 89, 101 and 113.

What is its magic constant?

Can you form these numbers into a magic square?

Solution next week

Live long and prosper

Could it be possible that another life form in the universe has a lifespan measured in many hundreds or thousands of our years?

Herman D'Hondt
Sydney, Australia

We don't even need to look elsewhere, as there are quite a few species on Earth with very long lifespans.

The oldest living individual land animal is a Seychelles tortoise, with an estimated age of 192 years. He is still going strong and may well live beyond 200 years. In the ocean, the longest-lived vertebrate is the Greenland shark, with a lifespan of several centuries. By carbon dating the inside of its eye, one individual has been measured at 392 years old, though it might have been about a century older or younger.

In the plant world, lifespans are much longer. Trees routinely live for centuries or millennia. A bristlecone pine in Nevada was around 4900 years old when it was felled. A quaking aspen in Utah is estimated to be around 15,000 years old. This tree is actually a forest of clones, interconnected by the root system and covering about 43 hectares. As such, it is also the world's largest "tree".

"Living bacteria have been found inside 2-billion-year-old volcanic rocks from South Africa"

Digging deeper in the tree of life, in northern Canada, living bacteria around half a million years old have been found in permafrost. In 2020, living microbes were found in suspended animation in submarine sediments dated from 4 million to 100 million years old. Living bacteria have been found in 2-billion-year-old volcanic rocks from South Africa. While they look much more primitive than modern bacteria, that doesn't mean they date from the time of the formation of the rocks – they are old, but not that old.

Finally, some species, such as hydras, don't grow old. Some hydrozoans can repeatedly revert from the adult stage back to the juvenile polyp stage. As a result, they may live forever, but nobody has observed them for long enough to know.

CAROLINE BURROWS/ALAMY

This week's new questions

Last peg standing **I recently bought multicoloured plastic clothes pegs. All but the yellow ones have slowly disintegrated in the sun. Why?** ***Nick Roxburgh****, Sydney, Australia*

Ancient mixtape **Is it known when humans or our ancestors first started to sing? And what is the reason for starting to do so?** ***Kevin Halford****, Pelt, Belgium*

Forest life

Why don't trees rot in the ground, while wooden structures do if they aren't properly built? (continued)

Joe Geesin
Kidderminster, Worcestershire, UK

The wood that provides the structural basis of trees is non-living, i.e. a dead material, but it is surrounded by living material that grows, regenerates and transports fluid and nutrients around the organism.

The living parts that surround the wood can respond to injury, regrowing before rot sets in. The tree also has an immune system, and much of it is covered with protective bark. Parts unprotected by bark have their own adaptations that allow them to survive and grow under those conditions.

That wooden fence post you hammer into the ground doesn't have any of that. It is just an organic material open to attack by sunlight, water, bacteria and insects, much like a fallen tree in the forest. Natural decay will be inevitable, the rate dependant on environmental conditions and what treatment the wood has had.

Keep the wood dry, handle it with care and cover it in a thick varnish and it will last for hundreds of years – look at any antique. But untreated wood in or around damp soil will be at the mercy of all the assailants mentioned above.

Why have all except my yellow clothes pegs disintegrated in the sun?

Curvy object

Is there a term for the shape shown below: a smooth, continuous curve with three axes of symmetry? And if anyone could share the equation for this curve, I would be very grateful. (continued)

ANDREW SEABY

Keith Parkin
Sheffield, UK

I don't know the equation nor the name (my Greek being insufficient) of the curve required. However, I can offer a relatively simple way to draw such a shape using a straight edge and compass.

Take an equilateral triangle and extend its sides out across the page. Now, draw an arc centred on a corner of your choice, connecting the two lines that protrude from it. Centring your compass on a second corner, draw a new arc that extends from the first and whose radius is equal to the length of the triangle side plus the radius of your first arc. Repeat the procedure until you rejoin your starting point.

This is a curve with interesting properties. Draw any two parallel tangents and they will always have the same separation: it is a non-circular shape with a constant diameter. In other words, if you had a square container with the same width, your plate could be packed inside in any orientation.

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist

THIS NEW DRONE CAN PASS DIRECTLY OVER THE VOLCANO'S MAIN VENT, ALLOWING YOUR TEAM TO COLLECT DATA FROM WITHIN THE ASH COLUMN.
THAT DOES SOUND SAFER.
SAFER THAN WHAT?
UH... NEVER MIND.
GOOD NEWS, KARL: YOU'RE A DRONE OPERATOR NOW.

The same procedure can be used for a similar construction with any triangle or regular, odd-sided polygon as a base. This is why coins such as 50 pence pieces can be used in slot machines – they are constant diameter curves. It also works in three dimensions: use a tetrahedron as a base for spherical caps, and you obtain a strange equivalent of a ball bearing.

Mel Earp
Macclesfield, Cheshire, UK
There are many equations that could approximate the shape of this object. Unfortunately, there is no simple Cartesian (x,y) form for this class of curve. However, it looks like an item of pottery that could have been handmade on a potter's wheel. If so, they would have first made a circular bowl, then, with the wheel stopped, teased the corners outwards and the sides inwards.

We can emulate this in mathematics. In this kind of shape, polar coordinates of the form (r,θ), with the radius r as a function of the angle θ, are much easier to work with.

"It looks like an item made on a potter's wheel with the sides teased inwards – we can emulate this in mathematics"

Suppose the bowl is about 25 centimetres across. Start with a circle whose polar equation is $r = 25$. This says that the radius is a constant 25. We then need to add a regular deformation to the circle, making sure that there are three lobes. The simplest mathematical wiggle is the sine wave. Suppose we want to add a 2.5-centimetre wiggle, but make sure that there are three lobes. The equation we want is $r = 25 - 2.5 \times \sin(3\theta)$. The negative sign is just to make it look the same way up as in the question. The "3θ" is what gives the shape its three lobes.

A more general form would be $r = a + b \times \sin(3\theta)$, where a and b are positive numbers with $a > b$. Here, "a" determines the overall size of the shape and "b" determines the size of the added deformation.

Robert Senior
Uppingham, Rutland, UK
I used to work for a company that made tubes, so we were interested in characterising how much an object's shape differs from a perfect circle.

The simplest component of "out-of-roundness" is ovality, where, around the circular shape, the deviation from a perfect circle is like two hills and valleys. The next component is tri-lobing, where there are three hills and valleys. I would describe the plate as circular with tri-lobing.

Since these deviations are like hills and valleys, if you plot them against the angle of rotation around the circle, they look like sine waves, so let's try adding a sine function to the equation of a circle.

In polar coordinates (r,θ), the equation of a circle of diameter D is $r = D/2$ for $\theta = 0$ to 360 degrees. Adding tri-lobing gives the equation of a shape like the plate as: $r = D/2 \times (1 + k \times \sin(3\theta))$, where k is a constant representing the amount of tri-lobing. ▮

Answers

Quick quiz #294 *Answers*

1 Venus

2 Cnidaria

3 Magnesium

4 Pūhāhonu

5 Vitamin K

Cryptic crossword #157 *Answers*

ACROSS 1 Blackout, **5** Clip, **8** Stele, **9** Dreamer, **11** Observatory, **13** Amends, **15** CT scan, **18** Transporter, **22** Lotuses, **23** Notch, **24** Earn, **25** Electrum

DOWN 1 Bose, **2** Anemone, **3** Keels, **4** Udders, **6** Limbo, **7** Partying, **10** Exalt, **12** Pastille, **14** Dusts, **16** Curator, **17** Fossil, **19** Actor, **20** Tonic, **21** Chum

#64 Matching tiles *Solution*

There are $3 \times 3 \times 3 \times 3 \times 3$ tiles, or 243.

Any pair of tiles forms a meld with exactly one other tile. There are 242 choices for the second tile and one for the last. However, this counts each meld twice, so there are 121 possible melds that include a given tile.

Each tile is part of 121 melds, making 121×243 possible melds. However, this counts each meld three times, so there are $121 \times 81 = 9801$ possible melds altogether.

Toy trouble

Feedback may be well into middle age, verging on dotage, but we aren't ashamed to admit that we enjoy playing with Lego, to the point of having a special cabinet in our home office in which to house our more prized sets. So, we were naturally intrigued to learn of a set, released on 1 March, called "The Evolution of STEM" (science, technology, engineering and mathematics).

The build is a cornucopia of STEM-related objects: a DNA double helix, a space shuttle, an apple tree with Isaac Newton stood nervously beneath it and more. They all erupt out of the pages of an open book, accompanied by minifigures of chemist Marie Skłodowska-Curie and agricultural scientist George Washington Carver.

It's a bit chaotic-looking, but there is a deeper problem, highlighted in a Reddit thread flagged to us by news editor Jacob Aron, and noted by at least one reviewer. It's quite simple: the DNA is the wrong way around. Many biological chemicals can be either left or right-handed, and in Earthly life, DNA is always right-handed – but Lego's DNA molecule is left-handed.

Feedback was going to suggest this was Lego subtly arguing that, despite what the experts say, we should go ahead and construct a mirror organism in which key molecules have the opposite handedness to existing life – even if it might kill us all. But then we saw that Jay's Brick Blog had already made that remark in their review.

So instead, we call on the world's palaeontologists to find something wrong with the metre-long *T. rex* skeleton kit Lego released on 15 March. We need to stop ourselves buying it.

Joined-up thinking?

With a certain weary inevitability, many big energy companies have rolled back their commitments to renewable energy, preferring to chase the immediate profits from fossil fuels.

In late February, BP announced it was boosting its investments in oil and gas by about 20 per cent, while cutting renewables funding by more than $5 billion. This was, it said, about maximising returns for shareholders. Alas, the firm's net income was a mere $8.9 billion in 2024. Oh, how their hands were tied.

On the day this announcement was made, the story was presented on the UK's *BBC News* homepage – next to one headlined "Half of homes need heat pump by 2040, government told". Feedback briefly joined some dots in our addled mind, before reminding ourselves that it's fine: the people in suits know what they're doing.

After all, BP isn't alone. A few weeks earlier, Shell released its full 2024 results, which noted that it had cut its capital spending on renewables from $2.3 billion to $2.1 billion. Last year, it abandoned its 2035 emissions target. Likewise, in December, Exxon set out a plan to boost its oil and gas output by 18 per cent by 2030.

To paraphrase *Futurama*'s Philip J. Fry: Feedback is shocked. Shocked! Well, not that shocked.

The whole saga leads us to wonder if "corporate strategy" might be an oxymoron on a par with "military intelligence". In the early 2000s, BP rebranded itself from "British Petroleum" to "Beyond Petroleum", to signal its intention to embrace renewables. Then it abandoned the whole thing after the 2010 Deepwater Horizon oil spill cost it a lot of money, bringing its focus back to fossil fuels. Fast-forward to 2020, and the company announced a raft of new renewables targets – many of which it is now slinking away from with this recent drop in funding.

Twisteddoodles *for New Scientist*

THE PEER-REVIEWERS' COMMENTS ON OUR RESEARCH PAPER ARE BACK. DO YOU WANT TO HEAR THEM?
ONLY IF YOU DO ALL THE VOICES!!
@twisteddoodles

Got a story for Feedback?
Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

If Feedback were this indecisive, we would, er, struggle to decide how to wrap this up, um.

Crunch the numbers

Reporter Michael Le Page draws our attention to *The Journal of Geek Studies*. Despite its (somewhat) formal-sounding name, it isn't peer-reviewed, but it will publish "any original contribution that combines an academic topic with something geeky".

Hence the paper that Michael found, published on 8 March, titled: "Is a bone a viable weapon when combating a Rancor? Estimating the bite force of an intergalactic mega-predator".

For readers unfamiliar with what a Rancor is, it's the great big reptile-like monster in the basement of Jabba the Hutt's palace in *Return of the Jedi*, which Luke Skywalker fights off. Another Rancor appeared in the 2021 series *The Book of Boba Fett*, but the less said about that the better.

Authors Thomas Clements and Stephan Lautenschlager seek to understand one key moment from *Return of the Jedi*. To avoid being eaten, Luke picks up a long bone and lodges it vertically in the Rancor's mouth, locking its jaw open. However, Luke's reprieve is only temporary, as the Rancor bites down so hard it snaps the bone in two.

Is this feasible? The pair simulate the muscles and bones of the Rancor's jaw and estimate it could bite with a force of around 44,000 newtons – "more than capable of vertically snapping a large long bone". Reassuringly, "no living vertebrate's bite force comes close to the Rancor", with great white sharks and saltwater crocodiles topping out around 16,000 to 18,000 newtons.

During our journalistic career, Feedback has repeatedly been told by editors to write stories that lead to practical advice, or "news you can use". Well, here it is. Readers: every time you venture into crocodile territory, carry a femur or two with you, just in case.

★ Trustpilot
Rated **Excellent** 4.7/5 from 1,500+ reviews

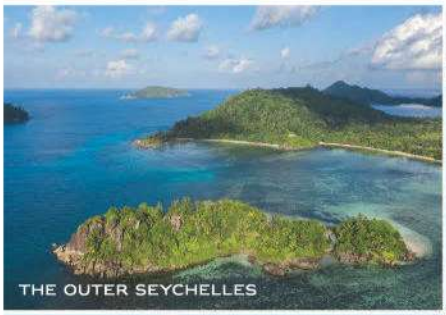
Connect to another network every time you lose signal

200+ apps with unlimited data
on EE, O2 and Three

Use alongside
your main SIM

Get Smart SIM now
honestmobile.com

honest


THE OUTER SEYCHELLES

AZORES ARCHIPELAGO, PORTUGAL

FLORIDA GULF COASTLINE, UNITED STATES

SYLVIA EARLE EXPLORES
COCOS ISLAND, COSTA RICA

THERE ARE OVER 130
HOPE SPOTS GLOBALLY

SYLVIA EARLE WITH VOLUNTEERS,
THE OUTER SEYCHELLES

GREAT BARRIER REEF, AUSTRALIA

MOBULA RAYS, AZORES
ARCHIPELAGO, PORTUGAL

SEA LION,
GALÁPAGOS,
ECUADOR

MISSION BLUE

ON OUR WATCH

Hope can now be spotted across all our planet's seas and oceans. Sites are made into aquatic havens by local communities, to safeguard the richness and diversity of the ecosystems they depend on. Sylvia Earle's invaluable experience as an explorer and marine biologist continues to help further their goal, through her organisation, Mission Blue. Together, they have created over 130 Hope Spots and counting. Carrying a message of hope for generations to come. It is that vision, that dedication to a perpetual planet, which we are proud to stand by. **For as long as it is needed.**

Rolex supports Mission Blue in its commitment to protecting 30% of the oceans by 2030.

#Perpetual

OYSTER PERPETUAL SEA-DWELLER

ROLEX
Perpetual Planet Initiative

ROLEX